

RESEARCH

Volume 9, Number 1

February 1999

MODE-LOCKED FIBER LASER FOR SAMPLING WIDEBAND ANTENNA SIGNALS

LT James M. Butler, USN

Associate Professor Phillip E. Pace

Professor John P. Powers

Department of Electrical and Computer Engineering

Introduction

We are studying *digital antennas*. As illustrated in Figure 1, these devices digitize the antenna signal with an electro-optic analog-to-digital convertor (ADC) and produces an output consisting of digital words of N bits at a word rate of M words per second. (Typically, we want N to be on the order of 10 bits and M to be 20 gigawords per second or higher [the exact rate must be at least twice the highest frequency of the received signal].) One technique to achieve such a high number of bits at such a high sample rate is with electro-optic techniques. A major benefit of these techniques is that no preamplification, signal downconversion, or processing is done before the digitization, since these add noise and nonlinear distortion to the signal. After digitization by the digital antenna, the data stream can be transmitted by a fiber-optic wavelength-division-multiplexed (WDM) link to a remote processor.

ADCs capable of digitizing a wide bandwidth portion of the radio frequency (rf) spectrum (e.g., a 10 GHz bandwidth) with sufficient accuracy (e.g., 10 bits) have been a long-sought goal for signals intelligence operations. Such ADCs typically include an operation that samples the rf signal with narrow pulses at a sampling frequency, f_s , before digitizing the samples. This sampling frequency, f_s , must be greater than or equal to twice the highest frequency contained in the rf signal, f_m (i.e., $f_s \geq 2f_m$), in order to meet the Nyquist condition that governs such sampling operations. For example, our representative 10-GHz-wide signal has a Nyquist sampling frequency of 20

gigasamples/s [GS/s]). Our research is currently investigating:

- the performance of optical pulse trains used to sample wideband rf and microwave signals,
- innovative techniques for digitizing the signal based on the properties of the symmetrical number system, and
- innovative optical digitizing architectures (i.e., an optical sigma-delta ADC).

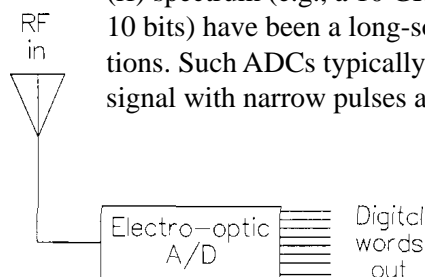


Figure 1. Digital Antenna Concept

IN THIS ISSUE

Featured Project	1
Menneken Award Winner	4
USW Research and Education	6
UAV Research	10
Research Lab	12
Research Centers	14,17
Navy/NASA	15
Project Notes	18
Technology Transfer	21
Student Research	22
Short Courses	26
Conferences	27
Faculty News	28
Conference Calendar	46
FY98 Research Program	47
Directories	48

NPS RESEARCH is published tri-annually by the Director of Research Administration in accordance with NAVSO P-35. Views and opinions expressed are not necessarily those of the Department of the Navy. Comments/inquiries can be addressed via email to research@nps.navy.mil.



NAVAL POSTGRADUATE SCHOOL

Superintendent

RAADM Robert C. Chaplin

Provost

Dr. Richard Elster

Associate Provost and

Dean of Research

Dr. David W. Netzer

--continued on page 2

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE FEB 1999		2. REPORT TYPE		3. DATES COVERED -	
4. TITLE AND SUBTITLE Naval Postgraduate School Research. Volume 9, Number 1, February 1999				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School, Monterey, CA, 93943				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES The original document contains color images.					
14. ABSTRACT see report					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES 48	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

FEATURED PROJECT

FIBER LASER, *continued from page 1*

This article focuses on the first topic of optical pulse trains used for sampling wideband rf and microwave signals.

Sampling Requirements for an Electro-Optic ADC

Actively mode-locked lasers can produce short-duration pulses in the picosecond and sub-picosecond range at high pulse repetition frequencies (PRFs) in the gigahertz regime. Mode-locked lasers can be constructed using solid-state lasers, semiconductor diode lasers, and fiber lasers. Fiber lasers are lightweight and use glass fibers and other

fiber-optic components common to the telecommunications industry to form a laser cavity. These mode-locked fiber lasers have demonstrated PRFs of 20 GHz at pulsewidths of one picosecond [1] and are ideal sources for optically sampling wideband signals directly at the antenna. Reducing the weight and power requirements for these optical devices becomes an important issue when considering mobile platform applications such as space-based signal collection.

Taylor [2] has studied the performance requirements of a binary-weighted optical ADC and has derived expressions for both the maximum allowed timing jitter and the maximum width of the sampling pulse.

-- continued on page 3

About the INVESTIGATORS

Phillip E. Pace is an Associate Professor in the Department of Electrical and Computer Engineering. He received his B.S. and M.S. degrees from Ohio University and his Ph.D. from the University of Cincinnati. Prior to joining NPS, Professor Pace worked in industry with General Dynamics Corporation, Air Defense Systems Division, and as a member of the technical staff at Hughes Aircraft Company, Radar Systems Group. Professor Pace is the recipient of the Hughes Aircraft Company Pull Study Fellowship, the Kroeger Foundation Fellowship Award, Outstanding Graduate Researcher of the Year Award for his Ph.D. work in signal processing and computing, NPS Outstanding Achievement in Research Award, and the Association of Old Crows Academic Training Award.

Professor Pace's research and teaching interests are in the areas of optical and image signal processing, electronic warfare, and weapons systems analysis. Professor Pace is Director of the Center for Joint Services Electronic Warfare Simulation and Modeling at NPS.



Phil Pace

John P. Powers is a Professor of Electrical Engineering. He received his B.S.E.E. from Tufts University (summa cum laude), M.S.E.E. from Stanford University, and his Ph.D. in Electrical Engineering from the University of California, Santa Barbara. He has been with the Department of Electrical and Computer Engineering at NPS since 1970. He has served as Chair of that department, Dean of Faculty, and Dean of Engineering and Computational Sciences. He is currently the Director of the Center for Reconnaissance Research.

Professor Powers teaches in the areas of electro-optics, fiber optics, and electronics. He has advised over 100 M.S. theses, five Engineer's theses, and two Ph.D. theses. Professor Power's research interests are in naval applications of optical devices, fiber optics, acousto-optics, scalar-wave diffraction, and acoustic imaging.



John Powers

FIBER LASER, continued from page 2

The maximum jitter, $\Delta\tau_{\max}$, that can be tolerated without incurring an error greater than one-half of voltage level (corresponding to one least-significant bit) is, $\Delta\tau_{\max} \leq 1/2^N \pi f_m$ where N is the number of bits in the digitized output and f_m is the highest frequency in the signal. For a representative 10-bit, 10-GHz-bandwidth ADC, the maximum allowable jitter is 31.0 fs. This femtosecond jitter requirement is challenging to meet.

The maximum pulse width that the sampling pulse can have (assuming that the sampling process computes the average of the signal voltage during the sampling pulse width) is $\Delta t \leq \sqrt{3/\pi} f_m^{-1} \sqrt{2^{N-1}}$. Our representative 10-GHz, 10-bit ADC requires that $\Delta t_{\max} = 2.44$ ps, a value that is fairly easily achieved by optical laser pulses.

Modelocked laser technology that combines dispersion control and nonlinear effects is able to generate high-frequency pulse trains with small amounts of jitter. Figures 2 and 3 show the experimentally measured jitter and pulse widths, respectively, for some operational modelocked lasers incorporating soliton-like pulse compression. (Generally, few experiments have measured the jitter of the lasers.) From the data, we note that the pulse width requirement of the sampling pulse train can be easily met, but that the femtosecond jitter requirement at high sample rates is more challenging.

Mode-locked laser performance characteristics that are

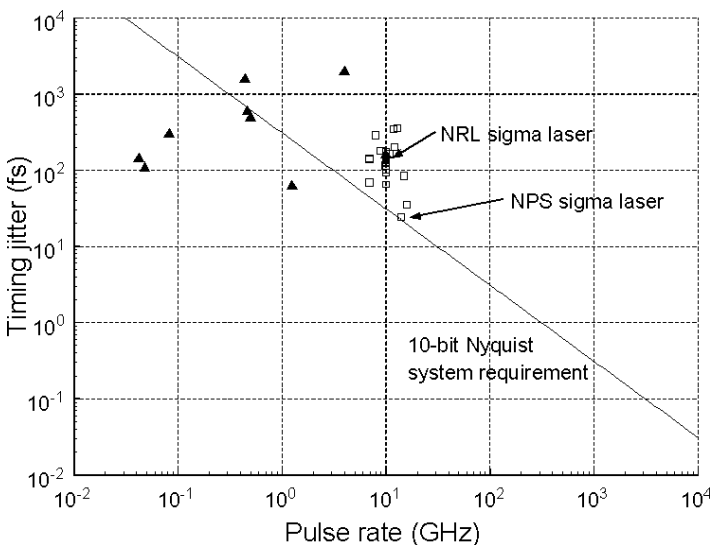


Figure 2. Experimentally measured laser jitter vs. pulse repetition frequency in modelocked lasers. Solid line is the theoretical requirements of a 10-bit ADC system sampled at the Nyquist frequency.

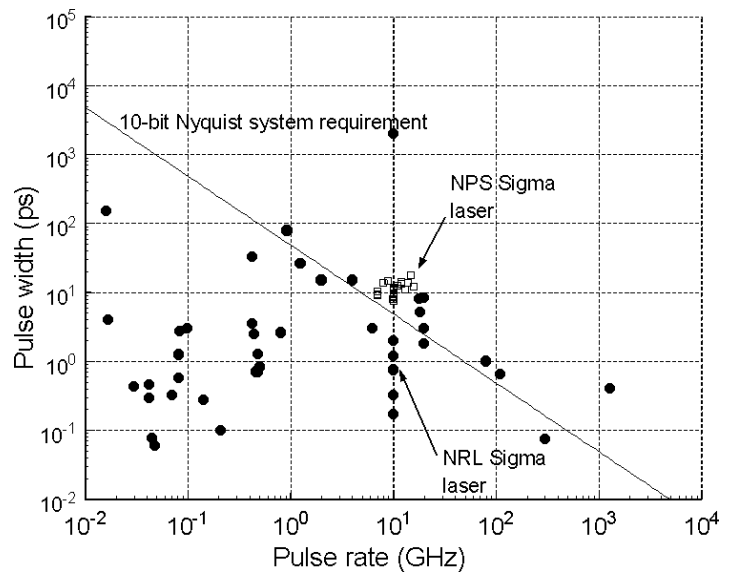


Figure 3. Experimentally measured laser jitter pulse width vs. pulse repetition frequency in modelocked lasers. Solid line is the theoretical requirements of a 10-bit ADC system sampled at the Nyquist frequency.

important in the direct sampling of antenna signals include low frequency and high frequency pulse-to-pulse time uncertainty (temporal jitter), amplitude uncertainty (amplitude jitter), the PRF, and the achievable laser pulsewidth. These parameters directly affect the maximum antenna frequency that can be Nyquist sampled and the bit-resolution of the resulting digital signal. This article describes the operating characteristics of a *sigma mode-locked fiber laser* for use in sampling wideband antenna signals on board a mobile platform. The term low-power is used since the saturated power out of the optical amplifier is only 51 mW. Measurements were carried out and algorithms developed in order to quantify the performance characteristics that are important in the direct sampling of antenna signals.

NPS Sigma Laser

The *sigma laser* is a fiber laser that combines active mode-locking with nonlinear fiber effects to promote pulse shortening [3,4]. The sigma laser was originally invented at the Naval Research Laboratory (NRL) for a 100 GHz time-domain multiplexed fiber optic communication system. The NRL laser uses an erbium/ytterbium (Er/Yb) co-doped fiber amplifier pumped by a 1 W neodymium (Nd) solid state laser and has a saturated output power of 200 mW. The NPS sigma laser (shown in Figure 4) is similar in design to the original NRL sigma laser except the fiber

-- continued on page 34

FEATURED PROJECT

DECISION SCIENTIST AWARDED MENNEKEN ANNUAL FACULTY AWARD FOR EXCELLENCE IN RESEARCH

The 1998 recipient of the Carl E. and Jessie W. Menneken Annual Faculty Award for Excellence in Scientific Research is **Hemant K. Bhargava**, an Associate Professor of Information Technology. Dr. Bhargava is a decision scientist, interested in developing ways to improve decision making through the application and combination of decision theory, analytical decision modeling, and information technology. His primary interests in decision making are in the development of decision technologies i.e., computer-based technologies that may be used to support a scientific and systematic approach to decision making.

Early Research in Decision Technologies

Dr. Bhargava's early research was in the development of formal modeling languages and formal systems for computer-based modeling. This research, begun during his days as a doctoral student in the decision sciences program at The Wharton School, University of Pennsylvania, was supported for several years by the U.S. Coast Guard under the Knowledge-based Decision Support Systems (KSS) project. The KSS team developed both specific decision

support tools as well as general concepts, methods, and tools for building decision support systems. The TEFA modeling system developed in Dr. Bhargava's doctoral research pioneered the use of hypertext in decision support.

Dr. Bhargava's other contributions in this area involved the use of dimensional analysis in modeling systems, formal type systems in algebraic modeling languages, integration of data modeling and mathematical modeling concepts, and the embedded languages technique for building large-scale modeling systems. This research also launched some long-lasting research collaborations with Professor Steven O. Kimbrough (his Ph.D. advisor at Wharton) and Professor Ramayya Krishnan at Carnegie Mellon University.

DecisionNet and Web-Based Decision Technologies

Dr. Bhargava's research took an important turn about five years ago following the emergence of the World Wide Web. At that time, the Web had begun to be viewed as an important medium for communicating information. The Bhargava-Krishnan team, however, saw a big opportunity: that of using the Web to transform the way decision technologies were delivered and used, via the creation of an electronic market for decision technologies. In such a

-- continued on page 5

About the INVESTIGATOR

Hemant K. Bhargava is an Associate Professor in the Informations Systems Academic Group. He received his B.A. from the University of Delhi, his M.B.A. from the Indian Institute of Management, Bangalore, and his Ph.D. in Decision Sciences from The Wharton School at the University of Pennsylvania. He joined the faculty of NPS in 1989.

Dr. Bhargava has published over 20 articles in several scientific journals, including IEEE Internet Computing, INFORMS Journal on Computing, Decision Support System, Interfaces, and the Journal of Organizational Computing. He has presented his work at several international conferences as well as at various universities including New York University, University of Texas at Austin, Northwestern University, University of California at Los Angeles and Berkeley, University of Washington at Seattle, Erasmus University (Rotterdam), Humboldt University (Berlin), and Hong Kong University of Science and Technology. Dr. Bhargava has advised over 30 M.S. theses on topics such as decision support systems, information networking, database management, artificial intelligence, and combat simulation.

Dr Bhargava is currently on sabbatical at Carnegie-Mellon and can be reached at bhargava@computer.org.



Hemant K. Bhargava

FEATURED PROJECT

DECISION MAKING, *continued from page 4*

market, decision technologies would be used as services, without requiring the user to own, install, or maintain the associated software. The platform independence and network-wide hypertext capabilities of the Web meant that the benefits of decision technologies could be delivered to users irrespective of their operating platform (hardware and software), or location. The DecisionNet project was launched with the objective of examining ways, and developing software infrastructure, for using the Web as a medium for deploying and delivering decision technologies. Simultaneously, Dr. Bhargava and his thesis students at NPS also set about experimenting with specific Web-enabled decision technologies such as a decision support system for developing optimal distribution plans for waste disposal and recycling.

Over the last five years, the DecisionNet project has involved several students both at NPS and at CMU, and other research collaborators including Dr. Rudolf Mueller at Humboldt University in Berlin. The DecisionNet team has investigated a number of research issues in the development of Web-based information systems in general, in the development of Web-enabled decision technologies, and in electronic commerce in decision technologies. Two research papers based on the Berlin collaborations on DecisionNet over the summer of 1995 and 1996 were winners of Best Paper Awards at the leading information systems conferences: the 5th International Workshop on Information Technology and Systems (Amsterdam, December 1995) and the 30th International Conference on System Sciences (Hawaii, January 1997).

Professors Bhargava and Krishnan have also recently published a feature article for the *INFORMS Journal on Computing* (Fall 1998) on the use of the Web in operations research and management science.

Work with the U.S. Marine Corps

Dr. Bhargava's most recent application of decision technologies to decision making in the real world involves manpower decisions in the U.S. Marine Corps (USMC). He was drawn into this area by a former student associated with a USMC effort to modernize their manpower decision making models and

information technology. His preliminary research on this topic involved a broad analysis of the methods and technologies presently in use in manpower modeling in the USMC, and culminated with a general set of recommendations for developing a next generation manpower modeling environment. In follow-up research, Dr. Bhargava and Associate Professor **Robert Dell** of the Department of Operations Research set about making improvements to two specific manpower decision problems: the problems of assigning enlisted personnel to jobs, and the problem (discussed further below) of assigning new Marine recruits to entry-level training schools. A peek into the work on the recruit distribution problem is illustrative of the issues and methods in developing decision technologies.

USMC Recruit Distribution Problem

Recruit distribution in the USMC is the process that assigns recruits to an entry level school leading to a military occupational specialty. These assignments are made about 48 times a year, during the last week of Marine Corps Recruit Depot (MCRD) training. Some schools have a class starting each week, others every month, and others only every quarter. New Marines, on the other hand, come out of MCRD training every week. Therefore, recruit distributions are made every week, but each run involves classes starting over approximately the next 12 weeks (see Figure 1). On the average, each run involves about 700 Marines and 500 classes with about 8000 seats.

When the NPS team began its research, the Marine Corp made recruit distribution decisions using a computer-based

-- continued on page 37

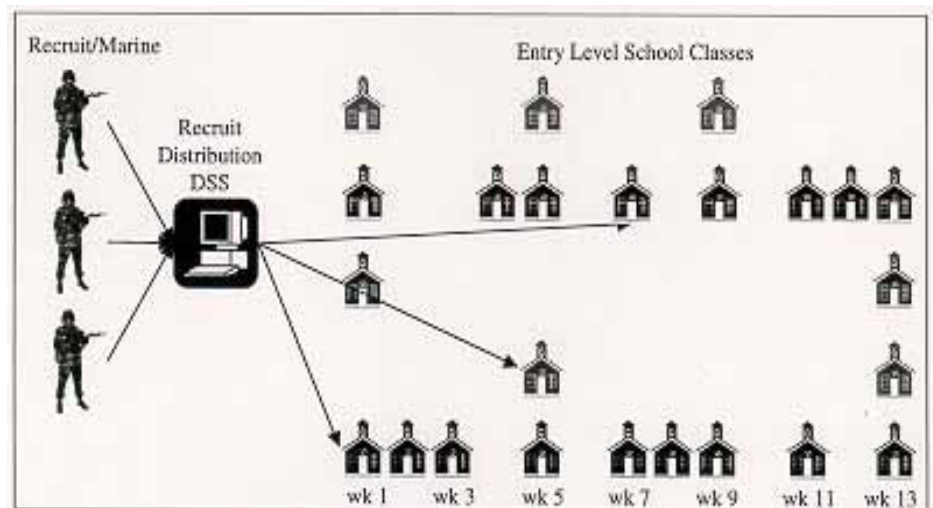


Figure 1. USMC Recruit Distribution Problem

RESEARCH AND EDUCATION

UNDERSEA WARFARE RESEARCH FOCUSES ON THE NAVY'S NEEDS

Research at the Naval Postgraduate School is an integral part of graduate education. It not only maintains upper division course content and programs at the cutting edge, it also provides students with challenges for creative problem solving experiences on DoD relevant issues and solves real-time warfare problems. Research is closely integrated into the Undersea Warfare Curriculum. Faculty and students are actively engaged in variety of research projects in the undersea warfare arena.

Littoral Ocean Acoustics

The limits of low-frequency sonar in a littoral ocean are imposed by complex ocean variability of multiple scales and the ambient sound field. Coastal fronts, river plumes and internal tides can cause the sound channel to fluctuate significantly, whereas scattering from internal waves limits the temporal and spatial coherence of the received signal. Low-frequency noise is dominated by marine mammals, shipping and wave-breaking processes in coastal waters. The resulting variability of the signal and granularity of the noise field, when predicted or fully characterized, can be exploited to enhance target detection and localization performances in a littoral zone.

To enable advanced sonar signal processing techniques and to capitalize on the space-time character of the sound and noise fields for undersea warfare purposes, the Naval Postgraduate School's Coastal Ocean Acoustic Laboratory (COAL) has been devoting its expertise and resources to study the physics of low-frequency, broadband sound propagation and the effects of environmental variability on signal stability and coherence in littoral waters since 1990. And since 1997, COAL has also been conducting studies of coastal ambient noise characteristics, particularly marine mammal sounds.

Headed by Professor **Ching-Sang Chiu**, Department of Oceanography, the primary research focuses of COAL are: 1) The characterization of meso to internal-wave-scale oceanographic processes that influence broadband sound transmissions in a coastal environment. Central to the characterization are the formulation of accurate forward relations and the quantification of the sensitivities and

UNDERSEA WARFARE CURRICULUM

The Undersea Warfare Curriculum educates officers in the engineering fundamentals, physical principles and analytical concepts that govern operational employment of undersea warfare (USW) sensors and weapons systems. The USW Curriculum grew out of the ASW program about five years ago broadening the scope of the program to include submarine warfare, mine warfare, and strategic undersea surveillance. The program is interdisciplinary and integrates mathematics, physics, acoustics, electrical engineering, oceanography, operations analysis, human factors, computer science, and meteorology.

The academic content divides naturally into four major specialty areas: Applied Physics with emphasis on underwater acoustics and weapons; Physical Oceanography with emphasis on environmental factors affecting acoustic and electro-magnetic surveillance, Engineering Acoustics with emphasis on signal processing, and Operations Analysis with an emphasis on tactical applications and decision analysis.

variability of the various observable acoustic quantities to environmental differences and changes. 2) The development and improvement of high-resolution tomographic inverse techniques for measuring the dynamics and kinematics of meso and finer-scale sound speed structure and ocean currents in coastal regions.

Using powerful, high-resolution observational tools and advanced processing, analysis and modeling techniques, COAL has conducted coastal experiments in various coastal regions including the Barents Sea and both the east (New England continental shelf, shelfbreak and slope) and west (central California) coasts of the United States. The experimental approach employed by COAL is both extensive and intensive, often involves significant collaboration and sharing of resources between several premiere oceanographic institutions and involves detailed and simultaneous measurements of physical oceanographic and acoustic properties during different months and at different geographical locations. These measurements are being related to physical oceanographic and acoustical modeling studies. Observational tools employed by COAL include moored programmable sound sources, moored/towed hydrophone arrays with real-time data telemetry and signal processing systems, volumetrically sensing acoustic tomography, rapidly surveying SeaSoars,

-- continued on page 7

UNDERSEA WARFARE, *continued from page 6*

Acoustic Doppler Current Profilers, and a former SOSUS array located at Pt Sur, California. The latter is known as the Naval Postgraduate School Ocean Acoustic Observatory (OAO).

To illustrate the type of measurements that are crucial to littoral-zone low-frequency acoustics research, results from a recent field study are shown in Figure 1. Sponsored by the Office of Naval Research, this coupled acoustics and physical oceanography field study is known as Shelfbreak PRIMER. The acoustic objective of Shelfbreak PRIMER is to understand the propagation of sound from the continental slope to the continental shelf including the effects of shelf-break frontal features and seasonal stratification. In

counterpart, the oceanographic objective is to characterize the mean and seasonal changes of the ocean circulation and to determine the kinematics and dynamics of the shelfbreak frontal processes. Carried out jointly by COAL and researchers from Woods Hole Oceanographic Institution, the measurement program of this integrated acoustic-oceanographic field study took place in the Middle Atlantic Bight south of New England. The field work included two intensive three-week experiments, one in July 1996 (summer) and the other one in February 1997 (winter). Specifically, each of the two experiments successfully employed a

-- *continued on page 8*

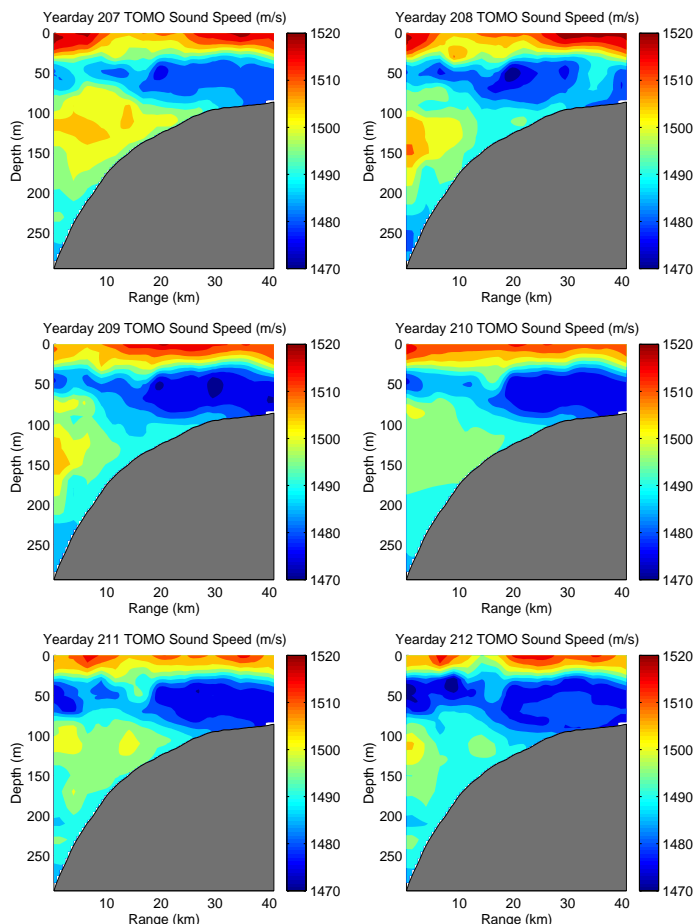


Figure 1. Daily sound-speed maps of the New England shelfbreak front derived from the acoustic tomography system deployed during Shelfbreak PRIMER, showing that cold shelf water was extending seaward, and the extension was temporarily reversed by an intrusion of warm Gulf Stream water on Yeardays 210 and 211.

SOURCE DEVELOPMENT FOR A SEISMO-ACOUSTIC SONAR

LT Sean M. Fitzpatrick, USN

**Master of Science in Mechanical Engineering and
Master of Science in Physics-December 1998**

**Advisor: Professor Thomas G. Muir, Chair of Mine
Warfare**

Buried mines in the beach and surf zone hinder Naval power projection, beach assault operations, and are unpopular for humanitarian reason. This thesis demonstrates that seismic interface waves on the surface of a natural beach can be used to unambiguously detect buried mine-like objects. Depending of the interface media, guided interface waves known as Rayleigh or Scholte are ideal for detecting shallow, buried ordnance in that they are localized and contain a considerable amount of seismic wave energy. The concept of using a seismo-acoustic sonar was further evaluated to detect buried ordnance in the beach and surf zone by developing an improved seismic source. Additionally, efforts were made to develop and refine testing procedures for follow-on research. The seismic waves were generated with two, 25-lb force-controlled linear actuators operated as shakers. The waves were measured with a two-element horizontal array of three axis seismometers. Buried mine-like objects ranging from 70kg to 290kg and at distances of up to five meters were echo-located by visual examination of the raw, recorded seismic signal or by using polarization filtering signal processing.

(LT Fitzpatrick returned to the fleet early in 1999 aboard the USS CONSTELLATION where he will serve as the Tactical Action Officer.)

RESEARCH AND EDUCATION

UNDERSEA WARFARE, *continued from page 7*

suite of new observational techniques including an acoustic tomography array consisting of multiple transceivers/sources and two vertical hydrophone arrays (VLAs) straddling the shelf-break front, several high-resolution, three-dimensional surveys of the frontal region with a SeaSoar, and a TOPEX/Poseidon flyover to coincide with one hydrographic section along the mooring array in the slope water. The resultant data set is both comprehensive and of high quality, and has allowed fundamental insights into acoustic propagation and the oceanographic processes which influence acoustic propagation in a slope-shelf region.

Mine Warfare

The Chair of Mine Warfare is currently occupied by Professor **Tom Muir** of the University of Texas at Austin

under an Intergovernmental Personnel Act Agreement. Dr. Muir and two of his recent thesis students, **LT Sean M. Fitzpatrick, USN**, and **Maj Patrick M. Hall, USMC**, researched the problem of the detection of naval and military mines that are buried in surf zone sediments and on land (beaches and soil). This problem has significant tactical implications for projecting naval power ashore. The ability of the Navy to safely land the Marines so they may conduct their amphibious assault mission, when and where needed, is a well-known and important aspect of Naval doctrine. Other applications of this research involve humanitarian de-mining of former war zones, as well as the remediation of unexploded ordnance at former naval and military bases. The approach taken in this research has been the development of the concept of seismic sonar for buried object detection. "Baby earthquakes" are created by a new technique developed at NPS that reflects off the buried ordnance, so as to reveal its range and bearing.

Once located, the ordnance can be avoided or neutralized by other means. LT Fitzpatrick developed a new force activator system to create the "baby earthquakes" needed to find the buried mines. His device is 1,000 times more powerful than any previous device used in micro-seismology. Maj Hall addressed the difficult topic of the target strength or reflectivity of buried ordnance, a key topic in the development of this technique. His measurements on the Navy Beach at NPS are among the first to document the target strength of mine-like targets.

Torpedo Countermeasures

Work on the design and testing of a low-cost, improved torpedo countermeasure (CM) using Digital Signal Processor (DSP) based technology, continues under the guidance of Assistant Professor **Don**

-- continued on page 9

TESTING AND DEVELOPMENT OF A LOW-COST, DIGITAL SIGNAL PROCESSOR (DSP) BASED TORPEDO COUNTERMEASURE (U)

LT Mark T. Evans, USN

LT Robert J. Jezek Jr., USN

Master of Science in Engineering Acoustics-September 1998

Advisors: Assistant Professor Donald P. Brutzman, Undersea Warfare Academic Group, and Professor Thomas G. Muir, Chair of Mine Warfare

The wide spread proliferation of modern submarines and torpedoes has significantly increased the threat to U.S. Naval Forces. Current U.S. torpedo countermeasures are not as effective against the latest generation of torpedoes. A new torpedo countermeasure is required to provide an acceptable defense against these new weapons.

The cost of any system is an important characteristic in today's restrictive fiscal policy. The use of commercial off-the-shelf (COTS) technology can significantly reduce development and procurement costs of any military program.

This thesis details the acoustic testing, troubleshooting and development of a new type torpedo countermeasure. This torpedo countermeasure is based on a Digital Signal Processor that allows a computer microprocessor to analyze a torpedo's sonar signal and generate an appropriate response signal as dictated by its programming. This gives flexibility that is a significant improvement over today's dedicated hardware systems and enables the device to outperform current countermeasures. Extensive use of COTS technology has minimized the cost of a prototype device. Computer simulation has played a large role in troubleshooting countermeasure software. Laboratory acoustic testing of the prototype hardware and software is described in detail, along with the resulting problems, proposed solutions and additional developmental steps.

UNDERSEA WARFARE, *continued from page 8*

Brutzman, Undersea Warfare Academic Group. **LT Chris Hand, USN**, is currently working on this project that was first proposed by **LT Martin Whitfield, USN**. The use of a commercial acoustic modem and commercial off-the-shelf (COTS) technology will enable a new CM to be built that is both lower cost and more effective than current fleet devices. LT Whitfield made substantial progress before completing his thesis in the Fall of 1997. **LT Robert Jezek Jr., USN**, and **LT Mark Evans, USN**, continued this work, testing and refining the prototype device built by LT Whitfield. New, more capable hardware will be delivered in Spring '99, and testing will move from the pools in the basement of Spanagel Hall at NPS to the waters of Monterey Bay. While waiting for the hardware to arrive, a graphics simulation is being built to test the software that will run the CM. This project covers a wide range of Engineering disciplines, including Acoustics, Computer Science, Electrical and Mechanical Engineering.

Underwater Acoustic Propagation

Recent efforts at Universite Denis Diderot and the Marine Physics Laboratory at Scripps Institution of Oceanography have demonstrated the feasibility of using Time Reversed Acoustic (TRA) techniques in shallow water waveguides. Experiments have shown that TRA can environmentally adapt the acoustic propagation effects of a complex waveguide in order to focus energy at a particular target range and depth. Additionally, TRA focusing can be done at useful ranges (30KM) and over reasonable time scales (30min) without updating the time reversed signal.

For underwater acoustic propagation, a monochromatic pulse generated by a point-like source excites several modes. Each mode travels at a different speed, so that the transmitted pulse gives rise to multiple copies, not equally spaced in time, arriving at a receiver. The TRA technique consists in digitizing the analog signal received by each element of an array of hydrophones, time reverse it, and retransmitting it from a co-located array of sources. For a wide-aperture array, the time reversed signal back at the point-like source is focused in time and space.

Thus, TRA can confine the transmitted acoustic energy to a narrow region that will track the intended receiver. These focusing and tracking features suggest that TRA may find applications in transponders, underwater communications, and active sonar. Furthermore, the high directivity of a

TRA array will suppress reverberation, highlighting strong acoustic scatterers.

Here at the Naval Postgraduate School, the full potential of TRA is being explored on tank-scale experiments in the Advanced Acoustics Research Laboratory in the Physics Department. With funding from ONR, an environmentally adaptive sonar technology using TRA is being currently investigated by **CDR Mitch Shipley, USN**, a member of the teaching faculty at NPS who has extensive USW operational experience on both fast attack and FBM submarines. **Lt Antonio Abrantes** (Portuguese Navy), under the supervision of Assistant Professor **Kevin Smith**, Department of Physics, is performing numerical simulations that probe schemes to increase data rates for underwater acoustic communications using TRA. The underwater communications schemes will be experimentally tested by **LCDR Michael Heinemann** (German Navy), under the supervision of Assistant Professor **Andres Larraza**, Department of Physics. De-reverberation techniques for applications to underwater communications and architectural acoustics are the thesis topic of **LT David Liddy, USN**, also under the supervision of Dr. Larraza.

ASW Strategies

N87 (OPNAV Submarine Warfare Division) has sponsored Research Associate Professor **Jan Breemer**, Undersea Warfare Academic Group, to examine the evolution of submarine- and anti-submarine warfare (ASW) strategy and operations in this century. A particular goal was to explore (a) how the ASW defender has historically gone about defeating the submarine's war-making purposes at the strategic and operational levels of war, and (b) whether this experience will be relevant into the next century. It was found that, despite vast changes in the submarine's technical war-making capabilities, the ASW defender's "menu" of strategic and operational choices has remained, by and large, unchanged. The strategic choices are to (a) destroy the submarine, (b) contain the submarine and its weapons, and (c) blunt the submarine's war-making efficiency. The defender's operational choices are to destroy, contain, or blunt the submarine's war-making efficiency at (1) its source (e.g., bases, building yards), (2) while in transit, and (3) while in its patrol area. Technology has served mainly to periodically re-arrange this basic matrix of nine choices.

This research led to the development of a new UW course, "Undersea Warfare in the Twentieth Century."

UNMANNED AERIAL VEHICLE (UAV) RESEARCH RAPIDLY EXPANDING AT NPS

Unmanned Aerial Vehicle (UAV) research has been ongoing at NPS for many years. In the past three years this program has rapidly expanded. The UAV program is a strong example of how NPS is utilizing the interdisciplinary capabilities of students and faculty to address the issue of how to best employ assets and new technologies that are rapidly increasing in capability and utilization.

As reported in NPS RESEARCH (Oct 98), NPS has joined into a cooperative agreement with the Naval Research Laboratory to foster the development of a joint program which will provide the Navy with the ability to effectively develop and utilize UAVs for Fleet operations. A meeting at NPS in October 1998 familiarized NPS faculty and students and NRL scientists with current capabilities, studies and future directions. Major components of the current NPS program are profiled below.

Center for Interdisciplinary Remotely Piloted Aircraft Studies

The NPS Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) provides UAV flight services to the research, development and test and evaluation communities, as well as support for the development of concepts of operations (CONOPS) and operational missions. CIRPAS is located at Marina Municipal Airport, California, a former military airstrip, and McMillan Airfield, Camp Roberts, California. The Camp Roberts facility is approximately 100 miles south of Monterey and provides an isolated geographical location with abundant clear airspace, freedom from signal interference and a clear air corridor to the Pacific Ocean.

Current assets include two Pelican OPV aircraft which are surrogate Predators that can be flown with a pilot or controlled by a Predator flight control system. This permits operations over populated areas. The Pelican can also be used to simulate a wide range of UAV configurations/capabilities. CIRPAS also has an Altus, high altitude UAV. Both of these vehicles are operated from a trailer-based ground control station. Satellite communications permit the sensor and flight data to be sent to the payload user at a remote site in near real time and permit the user to provide input to the ongoing flight. An UV-18A Twin Otter is also available for scientific missions, as an UAV chase plane, or a test bed for graduate courses in aerodynamics. In early 1999, CIRPAS will also receive two Predators from the Tactical Control Station Program.

EA-6B UAV Distributed Geometry in Information Operations

CAPT James Powell, USN, Chair of the Information Warfare Academic Group, is looking at UAVs from the Information Warfare/Information Operations (IW/IO) angle. He believes that the EA-6B plus distributed UAVs or UCAVs (Uninhabited Combat Air Vehicles) should be a large part of the vision for the future of Navy Tactical Air Electronic Warfare (TACAIR EW), whether as the ultimate follow-on, or as an interim replacement for the platform. This kind of distributed geometry answers a lot of the J/S and azimuth problems struggled with in the past, as well as EA-6B survivability and the issue of manned airplanes over the beach. So, it would allow some flexibility. The geometry factor applies to both threats where main beam positioning is required, and all kinds of communications where effective Electronic Attack (EA) will require closer stationing due to $1/R^2$ vs. $1/R^4$ range-J/S considerations coupled with spread spectrum where power and range-response time are factors (a repeater or follower will not work for fast-hoppers at longer ranges). UAV EA payloads have been built and tested which are inexpensive such as JC2WC PIONEER jammers, and Northrop-Grumman T-RECS. They don't have to be high-power or high-tech in a closer, somewhat expendable application managed by a smart platform. Also, when they radiate doesn't mean they're immediately killed, especially when there are many in numbers, and, these platforms should be recoverable. Something like TALD/MALD should be affordable in numbers, useable and cost-effective for training, and would pale in cost compared to a manned platform. There are spread-spectrum data links that could be used to manage a number of UAV/UCAVs from a controlling EA platform, but this would be in the command sense with semi-autonomous UAV flight profiles from a geo-type display. Another factor is EA-6B/UAV utilization in IW/IO, and not just SEAD. Access to networks in forward theaters of interest, and new means of telecommunications requires we look to offboard distributed geometries to modernize for future IO engagement. Lethal and loitering UAVs should also be factored in.

Two classified research projects have been completed on UAV EA payloads. **LT Tim Barkdahl, USN**, a student in the Department of Operations Research, is undertaking a

-- continued on page 11

UAV RESEARCH, *continued from page 10*

modeling and simulation thesis to show the delta in adding distributed UAVs to the EA-6B mission. Current research is looking at three aspects of this including a methodology to pursue the follow-on.

Modeling and Analyzing UAV Operational Sustainability and Effectiveness

From an operational, mission-oriented, viewpoint UAVs are an element and option of the C4ISR system that promise to provide useful, timely, and operationally relevant information economically and effectively, without jeopardizing the lives of pilots and other operators. A variety of decision-related issues influence the proper choice of UAV types, and force sizes and operational concepts. The purpose of the present research of Distinguished Professor **Donald Gaver** and Professor **Patricia Jacobs** of the Department of Operations Research is to provide initial tools for decision-makers to use to assess the net military value of a particular UAV force when embedded in a total C4ISR system, thus guiding the establishment and management principles for acquiring and using such a force.

It must be recognized that employment of UAVs in an operation entails commitment to support, i.e., maintenance and repair, logistics, appropriate payload configuration for particular mission objectives and replacement of lost UAVs. UAVs consist of platforms carrying an information-gathering payload (they need not all, or always should be

the same), the informational product of which must be transmitted to decisionmakers. Any of these elements are subject to unpredictable failure in operation, and hence experience diminished effectiveness and require maintenance. In-operation endurance is also limited by fuel constraints; however, fueling in flight on station may sometimes be an option. Operation and control of elements of a UAV force require remote attention and monitoring; the numbers and training of remote UAV "pilots" or operators requires systems study. Maintenance and at-base/on-ship refueling, and transit time to and from operational regions put requirements on the numbers of UAVs necessary to provide adequate coverage of those regions. To those requirements must be added the appropriate base-level support capacity (trained personnel, diagnostic and repair equipment, logistics); without this support an initially adequate force rapidly deteriorates. Sustainability of on-station presence as well as effectiveness while on station must thus both be considered and balanced to achieve maximum military effectiveness. The present research approach to this systems problem uses mathematical (probabilistic) modeling and optimization ideas. Computer simulation and search techniques are employed to identify system sensitivities and cost-effective tradeoffs.

Systems Technology Laboratory (STL) Potential for Fleet Connectivity

NPS CIRPAS' UAVs have communication capabilities on

-- continued on page 38

UAV CONOPS Development

Unmanned aerial vehicles will play an important role in future naval operations, but operational concepts need to be worked out. Professor **Alan Washburn**, Department of Operations Research, is examining one of the many tasks that UAVs might undertake: Surface Search and Surveillance (SSC).

UAVs will undertake tasks that are dangerous, dirty, and/or dull. SSC is one of the dull kinds. A battle group must keep track of all contacts within several hundred miles of PIM (the group center). Contacts are easy to detect by active means, but must still be overflown to establish identity and intent. A vertical takeoff and landing (VTOL) UAV based on a helicopter platform can make a significant contribution to accomplishing this SSC mission. The UAV's role will be to make repeated flights, each of which visits

one or more targets of interest. The utility of the UAV will depend on its sensors, its speed and endurance, its command and control system, its method of prioritizing targets, and on unrelated parameters such as target density and battle group speed. The Monte Carlo simulation UAV_SSC developed in this project is designed to facilitate assessment of UAV utility.

UAV_SSC is a Visual Basic simulation of a UAV in the SSC role. It has both graphic and statistical modes, with the latter being the former speeded up by omitting the pictures. It simulates a battle group proceeding at a fixed speed and direction through a sea containing targets proceeding at a different fixed speed and in random directions. Targets entering the battle group's envelope eventually are visited by the UAV, perhaps repeatedly if they are "bad guys." UAV_SSC is available from the author at washburn@nps.navy.mil.

METEOROLOGY LABS HAVE A GLOBAL REACH

Six major laboratories serve the Department of Meteorology instruction and research mission. They are the:

- Interactive Digital Environmental Analysis (IDEA) Laboratory, an interactive computer workstation laboratory,
- Synoptic/ Mesoscale Analysis and Forecasting Laboratory,
- Marine Atmospheric Boundary Layer Laboratory,
- Numerical Modeling Laboratory,
- Tropical and Monsoon Laboratory, and
- Remote Sensing Laboratory.

While these laboratories are used to support the instruction of the METOC curricula, they also play a critical role in vigorous research programs within the department. During FY98 the Department of Meteorology's nine tenure track and nine research faculty executed almost \$2.8 million of research activity. Major research sponsors for this work include the Office of Naval Research (ONR), SPAWAR, National Science Foundation (NSF), Naval Research Laboratory (NRL) and NASA. The Navy's need for atmospheric research is global. Thus, the department's research laboratories have a global reach. An overview of recent research activity in some of the laboratories follows:

Tropical and Monsoon Research Laboratory

The Tropical and Monsoon Laboratory led by Professors **C. P. Chang**, **R. T. Williams** and **Tim Li** studies a range of time scales of the global and tropical circulations, from synoptic scale monsoon onset and break events and mesoscale disturbances to interannual variations including the El Nino-Southern Oscillation. In addition to NPS faculty, research staff and students, visiting scientists from the People's Republic of China, Taiwan, Hong Kong, and Singapore used the laboratory during 1998.

The mesoscale and synoptic scale studies are sponsored by ONR. In the tropical lab the one focus of study is disturbances that develop during the onset and mature stages of East Asian monsoons, that produce disturbed weather in the South China Sea, East China Sea, South and Central China, Korea Peninsula and Japan. Both observational, diagnostic work and numerical modeling occur in the laboratory. The observational work was helped by the recent launch of the South China Sea Monsoon Experiment; an international field program participated in by the U.S., Australia, and many East and Southeast Asian nations. (Professor Chang is the co-chair of the U.S. SCSMEX Science Working Group and a member of its International Organizing Committee). The observational results are being analyzed and simulated by Navy's regional numerical forecast models to elucidate the structure and mechanisms of these weather-producing disturbances.

NSF-sponsored interannual and climate scale studies as well as certain theoretical studies are conducted in the laboratory as well. A recent observational study revealed the relationship between the East Asian monsoon properties and the tropical sea surface temperature in the eastern and western Pacific and the South China Sea. A theoretical work, based on the land-atmosphere-ocean interactions in the tropics, resolved a long standing problem on the spatial and seasonal structure of the observed troposphere biennial variation of the monsoon strength over Asia and Australia and sea-surface temperature anomalies in the tropical Indian Ocean and Pacific. An extension of the theory is being proposed in which the interactions between this oscillation and the El Nino - Southern Oscillation may explain the recent failure in predicting the effect of the 1997-98 El Nino on Australian and Asian rainfall.

Everywhere the Fleet is exposed to the threat of tropical cyclones. Weather data also flows into the tropical laboratory for studies to improve warnings. The primary operational partner in this effort has been the Joint Typhoon Warning Center, Guam, which has responsibility for all Northern Hemisphere cyclones west of the dateline and for all Southern Hemisphere cyclones. The ONR Marine Meteorology Program has provided long-term funding for this research, and the NRL-Monterey and Fleet Numerical Meteorology and Oceanography Center have provided expertise and data, most in real-time for use by faculty and students.

A recent M. S. thesis by Meteorologist **Mark Boothe** extended the Systematic Approach concept of Research Associate Professor **Lester Carr** and Distinguished Professor **Russell Elsberry** to the eastern and central North Pacific tropical cyclones. Two extended visits by an Australian Bureau of Meteorology forecaster, Tony Bannister, have resulted in a meteorological knowledge base for the Southern Hemisphere cyclones. Research in progress by M. S. thesis student, **LT Dave Brown, USN**, will apply the Systematic Approach concept to Atlantic hurricanes, in support of the Navy Meteorology and Oceanography Command

-- continued on page 13

METEOROLOGY LABS, *continued from page 12*

forecasters in Norfolk, VA, and Jacksonville, FL. Long-term funding from ONR and SPAWAR is supporting the development and testing of a knowledge-based expert system that will apply the Systematic Approach concepts.

Ph.D. student **LCDR Pete Klein, USN**, is extending his previous studies on the midlatitude cyclones that evolve from decaying tropical cyclones. Research Associate Professor **Pat Harr** and Research Assistant Professor **Liz Ritchie** are conducting observational and numerical simulations on these "extratropical transitions" that may threaten Navy or other maritime units. They are also using observations and models in the laboratory to study the formation of tropical cyclones. Thus, whether the tropical cyclone is just forming, at Supertyphoon intensity, or decaying to become an extratropical cyclone, one of the Department of Meteorology tropical laboratory and researchers are active collecting the data for research studies to improve warnings of these dangerous storms.

Marine Atmospheric Boundary Layer Research Laboratory

Understanding properties of the atmospheric boundary layer is important for Navy operations because of its impact on radar and optical (EM/EO) propagation and its role in energy exchange to Upper Ocean and Arctic ice surfaces. Three Meteorology faculty members perform research with observational and physical modeling studies in the Marine Atmospheric Boundary Layer Laboratory to gain knowledge on properties and processes responsible for them. They work with data from different platforms deployed in a wide range of locations. The faculty are Professor **Ken Davidson** (Research vessels and buoys in coastal re-

gions), Assistant Professor **Qing Wang** (Aircraft in open ocean and arctic regions), and Research Assistant Professor **Peter Guest** (Icebreakers and Ice camps in Antarctic and Arctic regions).

Professor Davidson and his group perform observational studies designed to answer basic research questions as well as to establish operational models for atmospheric near-surface gradients of temperature and aerosol that affect radar and optical propagation. Group staff members are **Paul Frederickson** who performs analyses and interpretation on data as well as designs collection strategies, **Keith Jones** who is responsible for measurement system design and installation, and **Tamar Neta** who designs the architecture of large multivariable databases and coordinates their use within multi-group experiments. Currently, sponsors of five different projects within this research are ONR and the Space and Naval Warfare Systems Command. All field and analyses/ interpretation efforts are performed in collaboration with other groups because of the complex and multivariable nature of phenomena being studied. In the past, primary platforms were research vessels, from European as well as U.S. institutions. In the past five years, the primary platform has been buoys instrumented to measure surface wave, as well as airflow properties, (Figure 1). A complete

--continued on page 42

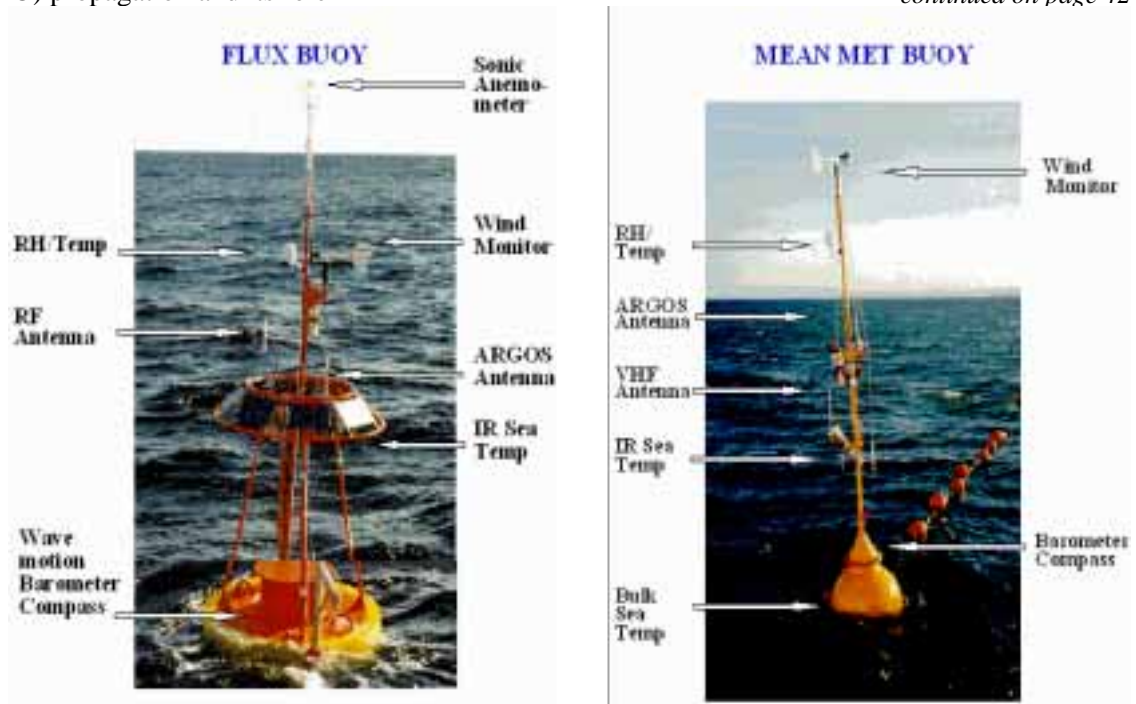


Figure 1. Buoys are instrumented to measure surface waves as well as airflow properties.

NAVY-NASA JOINT INSTITUTE OF AERONAUTICS

The Navy-NASA Joint Institute of Aeronautics was established in July 1986, following the signing of a Memorandum of Understanding between the Naval Postgraduate School and NASA Ames Research Center (ARC). Direct participation of NPS students in the ongoing research projects at ARC is a hallmark of the Joint Institute. The Joint Institute has:

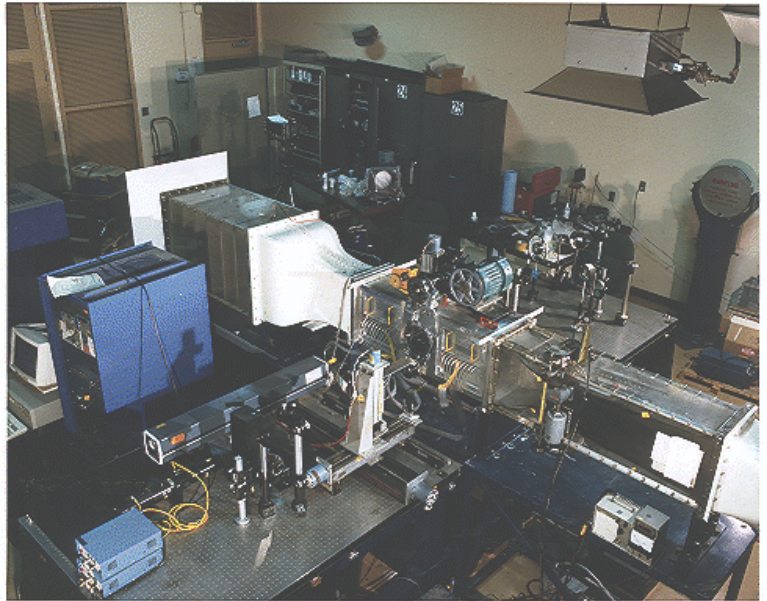
- fostered communication between NPS, other DoD agencies and ARC
- been responsible for significant bilateral exchange of scientific information through courses and seminars
- created excellent thesis opportunities for NPS students and special research opportunities for post-doctoral fellows and visiting research scientists, at ARC

Distinguished Professor **Max Platzer** has been the Director of the Institute since its inception. The Associate Directors are Research Professor **M.S. Chandrasekhara** of NPS and Mr. D.P. Bencze of ARC. Current research staff includes Research Assistant Professor **Kevin D. Jones** of NPS and Dr. M.C. Wilder, Senior Research Scientist of MCAT, Inc. ARC participants include Dr. S.S. Davis and Dr. L.W. Carr, Emeritus Scientist, U.S. Army Flight Dynamic Directorate.

A major benefit of the arrangement for all participating organizations is the maximization of the returns per invested dollar through the sharing of joint resources of ARC and NPS with the project sponsors. The benefits to NPS include:

- availability of NASA expertise to NPS students
- availability of NASA research and test facilities to NPS students
- exposure of DoD project officers to current R&D projects of national interest as well as to future aerospace technologies
- interactions of NPS faculty and students with ARC scientists on projects of mutual interest
- availability of ARC scientists as instructors for specialized courses and as thesis co-advisors

The ARC facilities are also used during field trips arranged in two NPS laboratory courses. One of these is an introductory course offered during the preparatory phase of the Aeronautical Engineering curriculum. The other ad-



The Navy-NASA Joint Institute's Compressible Dynamic Stall Facility located in the Fluid Mechanics Laboratory of NASA Ames Research Center

vanced course discusses the latest measurement techniques such as laser velocimetry, laser interferometry, neural networks and micro-electro mechanical sensors (MEMS). The field trips highlight full-scale testing, cockpit simulation, hypersonic flow measurements and spacecraft thermal protection during re-entry.

Major research projects conducted in the Institute involve fundamental and applied science in aerodynamics and aeroelasticity. The problem of dynamic stall and loss of lift during maneuvers has limited the flight safety envelope of helicopters and fighter aircraft. It has been extensively studied in the Compressible Dynamic Stall Facility, a special purpose wind tunnel developed in the Institute with funding from AFOSR, ARO and NASA. A means of controlling this phenomenon has now been developed using real time wing shape adaptation as needed, with further research aimed at automated control. Concurrently, modern computational methods have been applied during the study of this problem to aid the development of novel flow control schemes. Other past experimental and computational studies in the Institute have investigated flow over modern fighter/attack aircraft and missile configurations under high alpha conditions. These involve asymmetric vortices over the wings, which may burst thus giving rise to structural, stability and controllability problems. Presently,

--continued on page 15

NAVY-NASA, continued from page 14

studies are ongoing to accurately predict this phenomenon. Other research studies in the Institute have focused on flutter and dynamic response characteristics of wings and missiles over all speed ranges. Recently, the analysis of flapping wing aerodynamics has been studied since it has applications to the development of micro air vehicles. At the flow conditions for this problem, completely new physics needs to be understood.

Past research associates contributing to these investigations supported by the Army Research Office, Air Force Office of Scientific Research, NASA-ARC, NASA-Lewis,

Naval Air Warfare Center, Office of Naval Research, Naval Air Systems Command, and NPS include the late Dr. S. Bodapati, Dr. S. Ahmed, Dr. J.A. Ekaterinaris, Dr. S.K. Hebbar, and Dr. I.H. Tuncer., Dr. W. Geissler (DLR-Göttingen), Dr. J.C.S. Lai (Australian Defense Force Academy), Dr. W. Sanz (Technical University of Graz), Mr. R. Walz (Technical University, Karlsruhe) and currently, Dr. S. Weber (German Research Foundation).

The results of these investigations have been published in over 50 M.S. and Engineer's theses, 2 Ph.D. theses, over 100 journal articles, 100 conference presentations and many invited seminars and symposia.

RELATIONSHIPS WITH NASA EXTEND INTO SEVERAL AREAS AT NPS

NPS' collaborative efforts with NASA extend beyond the Navy-NASA Joint Institute. NASA sponsors a Chair Professorship, was extensively involved in the launch of the NPS-built Petite Amateur Navy Satellite (PANSAT), and sponsors research in the Departments of Aeronautics and Astronautics, Computer Science, Meteorology, Mechanical Engineering, and Oceanography.

Petite Amateur Navy Satellite

The Petite Amateur Navy Satellite, PANSAT, was

successfully launched on the STS-95 (Discovery) Shuttle mission, October 29, 1998. The small digital communications satellite, built by the Space Systems Academic Group (SSAG) as an instructional/research hardware project, was deployed October 30, 1998, into a circular, low-Earth orbit with 555 km altitude and 28.45° inclination.

Spacecraft operations are performed by the NPS SSAG and currently include monitoring spacecraft performance. Software uploads in the near future will provide additional capability and services, such as the spread spectrum

bulletin board system that will be available to the amateur radio community. Officer students will be exposed to actual spacecraft operations as well as engineering details of the project, including communications using spread spectrum techniques, nickel-cadmium battery technology, orbitology, and other spacecraft technology.

NPS worked with NASA Goddard Space Flight Center through the DoD Space Test Program (STP) as a Hitchhiker payload. SSAG staff worked with STP and NASA/GSFC personnel to resolve all integration and test, interface, operations, and safety issues associated with the Shuttle orbiter. PANSAT was manifested on STS-95 as part of the third International

--continued on page 16

NASA Michael J. Smith Space Systems Chair Professorship

The "NASA" Chair at NPS was established by Memorandum of Agreement in 1995. The Chair was established in memory of astronaut **CAPT Michael J. Smith, USN**, an alumnus of NPS. The purpose of the Chair Professor is to add a faculty member to the Space-related curricula at NPS to enhance the education of the NPS students.

The current chairholder, Dr. **Charles Daniel**, recently joined NPS. Dr. Daniel's experience at NASA includes developmental work on the Saturn V, Space Shuttle, and the International Space Station. During his tenure at NPS, Dr. Daniel plans to:

- establish an active research link between NPS and NASA and to initiate research activities supported by NASA at NPS
- facilitate senior management from NASA in visiting and establishing a continuing relationship with NPS
- develop seminar material to supplement the areas currently covered at NPS and to integrate this material into the NPS environment
- establish a relationship with the students and faculty at NPS to allow them to become aware of the activities NASA has underway and to develop potential downstream cooperative activities.

NAVY-NASA, *continued from page 15*

Extreme-ultraviolet Hitchhiker (IEH-3) payload which consisted of the following six individual experiment payloads.

- Solar Extreme Ultraviolet Hitchhiker (SEH), managed by University of Southern California
- Ultraviolet Spectrograph Telescope for Astronomical Research (UVSTAR), managed by University of Arizona
- Space Telescope for Astronomical Research (STAR-LITE), managed by the University of Arizona
- Solar Constant Experiment (SOLCON), managed by the Royal Meteorological Institute of Belgium
- NPS' Petite Amateur Navy Satellite (PANSAT), managed by the Department of Defense Space Test Program
- Get-Away Special (GAS) G-238 and G-764 Payloads

Tropical Mesoscale Weather Disturbances

Professor **C.-P. Chang** of the Department of Meteorology is working with Dr. W. Tim Liu of NASA/JPL in using the NASA Scatterometer (NSCAT) ocean surface wind data to study mesoscale tropical weather disturbances. The NSCAT data provided high-resolution (25 km) surface winds over many parts of the ocean between September 1996 and June 1997, which was the first time surface winds over large parts of tropical ocean were observed. Chang, Liu and their colleagues are experimenting with methods to use the data to analyze tropical convective weather systems and their numerical prediction. The challenge is that single-level winds at the surface without space and time continuity, and not as a part of a four-dimensional data assimilation, are quickly overcome by the model dynamics once the numerical integration is underway. For tropical mesoscale systems, initializing the sea-level pressure from the surface wind is also impractical due to the decreased validity of the geostrophic or gradient wind relationship. The investigators are studying flow regimes that are associated with mesoscale heavy precipitation near terrain in tropical monsoon settings, so effects of small surface wind differences over a localized area can be amplified by the moisture and terrain effects. The experiments are carried out with the help of Dr. C. S. Liou of the Naval Research

Laboratory, using the Navy's operational numerical weather prediction models.

Thermoacoustic Effects at a Solid-fluid Boundary and Acoustic Streaming in Microgravity

This research, sponsored by the NASA Microgravity Program and being investigated by Assistant Professor **Ashok Gopinath** of the Department of Mechanical Engineering, centers around the study of non-zero time-averaged thermo-fluid phenomena induced by the interaction of a zero-mean oscillatory flow (as in a high intensity acoustic field) with a rigid boundary. The studies are motivated by the need to be able to understand the potential of manufacturing ultra-pure isotropic materials in space by containerless materials processing wherein the process is unaffected by contamination and other boundary effects, and unbiased by the presence of gravity and the resulting buoyancy field. There is also a concomitant goal to investigate the role of, and the possibility of measuring, a little known second order thermal expansion coefficient which arises in this analysis, and is known to be an important thermodynamic modulus in the chemical industry. Based on the findings from this study, suggestions will be made for future flight experiments in space.

Arctic Clouds and the Surface Energy Budget

Assistant Professor **Qing Wang**, Department of Meteorology has been involved in the joint experiment of the First ISCCP (International Satellite Cloud Climatology Project) Region Experiment, Fire III, and the Surface Heat Budget of the Arctic Ocean Experiment (SHEBA). The experiments, sponsored by NASA, the Office of Naval Research, and the National Science Foundation, intend to understand the energy budget of the Arctic and the feedback processes among atmosphere-ice-ocean in the Arctic. The study is essential to accomplish NASA's mission in understanding the cloud systems and improve cloud retrieval from satellite remote sensing in the Arctic area. Understanding the Arctic environment is also crucial to the Navy's underwater operation in the high latitudes.

The experiments included a yearlong ground measurement based on an ice camp, multiple research aircraft, satellites, and research ships. Professor Wang is involved in the aircraft measurements and data analyses being collected by a C-130 research aircraft. The specific objective of Professor Wang's research is to examine the inhomogeneity of surface

--continued on page 45

NATIONAL GUARD ESTABLISHES EDUCATION AND RESEARCH PROGRAM WITH THE CENTER FOR CIVIL MILITARY RELATIONS

The National Guard has established a multi-year education and research program with the Naval Postgraduate School's Department of National Security Affairs and the Center for Civil Military Relations. The program will develop a distance learning Masters Degree Program in International Security and Civil-Military Relations (Curriculum 689) for National Guard officers participating in international military operations other than war. More than 25 states provide National Guard units in support of the Partnership for Peace program alone; hence, there is a significant population of officers that need this kind of education. In addition, a smaller number of officers will attend the Curriculum 689 completely in residence. By the time the program is fully operational, after FY03, more than 50 National Guard officers will be participating at any one time.

Equally important, the program provides substantial resources for research into civil military relations issues that affect or include the National Guard and the reserve components in general. As **LTC Jon Czarnecki**, acting senior National Guard advisor to the Naval Postgraduate School, has said, "While there is substantial historical research on the role and missions of the National Guard and other reserve components in the area of civil military relations, there is little meaningful social science research in this same area. With the current defense trends leading to increased reserve component participation in national security and military strategic affairs, this hole in the research literature must be filled. Why not begin the effort at the best military graduate institution in the country?"

In FY99, NPS will receive \$575,000 for curriculum and course development, student tuition, and research. This amount is programmed to increase to over \$1,000,000 in FY03. The National Guard will provide an additional staff officer to assist the Center for Civil Military Relations in the management of the educational program and the research.

INSTITUTE FOR JOINT WARFARE ANALYSIS CITED FOR PARTNERSHIP WITH PACIFIC GROVE FIRE DEPARTMENT

Each year since 1995, the Federal Emergency Management Agency (FEMA) has published a compendium of exemplary practices in emergency management throughout the nation detailing how communities have built partnerships and implemented innovated programs to address specific areas of emergency management. For the second year in row, the City of Pacific Grove, California, was cited for their activities in emergency preparedness. In 1998, Pacific Grove was one of 49 communities in the United States cited for "Partnership for Preparedness Against Terrorism."

A partnership between the Pacific Grove (PG) Fire Department and the Naval Postgraduate School's (NPS) Institute for Joint Warfare Analysis (IJWA) has been formed to examine the methods of response by local authorities for terrorist attacks using chemical and biological weapons of mass destruction. NPS and the PG Fire Department along with other local organizations have begun a program to collect real-world data on response and reaction times during the first critical hours of crises reaction. These data will be useful for scenario analysis and local response improvements. The first exercise, with 65 "victims" was held in November 1997. It employed ten fire engines from seven nearby cities, five ambulances, a medical helicopter, the facilities of four hospitals, the PG Police Department, California Highway Patrol, Monterey County Coroner, amateur radio operations, three Red Cross Emergency Response Vehicles, and a Salvation Army Canteen Vehicle. The data collected from this event and the conceptual response model are documented in two IJWA technical reports, *Pacific Grove Multi-Casualty Incident Drill, 22 November 1997* (NPS-IJWA-98-003), and *Multi-Casualty Incident Exercise Modeling, Data Acquisition and Parameters*, (NPS-IJWA-98-005).

Professor **Gordon Schacher**, NPS Professor and Director of IJWA, NPS Professor **Xavier K. Maruyama**, and Dr. Russell Coile, Pacific Grove Emergency Program Manager, are the principals involved in this effort. The FEMA citation is contained in *Partnerships in Preparedness, A Compendium of Exemplary Practices in Emergency Management*, Volume III, October 1998. The report can be found at <http://www.fema.gov/library/lib07.htm>.

Additional information on the Institute for Joint Warfare Analysis can be found at:
<http://www.stl.nps.navy.mil/~cullen/IJWA>

PROJECT NOTES

MANAGEMENT SYSTEMS FOR HETEROGENEOUS NETWORKS (MSHN): MANAGING NEXT GENERATION MILITARY COMPUTER APPLICATIONS

Assistant Professors **Debra Hensgen** and **Taylor Kidd**
Department of Computer Science

The Management System for Heterogeneous Networks (MSHN, pronounced "Mission") team recently met in Fredericksburg, VA, for the quarterly MSHN Investigators meeting and a research meeting at the Naval Surface Warfare Center (NSWC) in Dahlgren, Virginia. Six investigators, 18 students and 5 staff members attended both of the meetings. Many of the individuals in attendance presented and brainstormed their research: past, present, and future. These research meetings serve to unite this diversely talented group, as well as invoke excitement about new avenues of research, and solving research issues that stump fellow researchers.

The visit to NSWC-Dahlgren was highly successful. The MSHN team received an all-day briefing concerning technical distributed computing problems that will be faced by the Navy in its efforts to implement the Next Generation AEGIS radar and coordinated weapons systems on COTS, networked computers. The major problems include resource management, which MSHN is seeking to address, and process group synchronization and communication, which is also a major research area within NPS' Computer Science Department.

Background

The MSHN research project is tackling some of the fundamental issues that must be resolved for the Next Generation Internet (NGI) project. The MSHN project is funded by DARPA and led by NPS Computer Science Assistant Professors, **Debra Hensgen** and **Taylor Kidd**. In collaboration with Purdue University, University of Southern California, and NOEMIX Corporation, the MSHN team is developing an architectural framework, and researching the issues necessary to build a resource management system, to take advantage of and efficiently make use of the heterogeneous computing environments of the present and, especially, those of the future.

Military applications are being developed that will be extremely heterogeneous, resource-intensive, and adaptive. Applications for combat simulation target recognition, weapons control, and high-bandwidth multi-media demand

a high Quality of Service (QoS). That is, they have certain computation, memory and network bandwidth requirements for adequate performance. The applications are heterogeneous because they require varying levels of resources in order to accomplish their goals.

Computing platforms of today are extremely heterogeneous as well, both in operating system design and underlying hardware design. From hand-held "palm-sized" computers to IBM's Deep Blue supercomputer, computing resources vary in many different ways. Networks are just as heterogeneous, from high-speed local area networks to relatively low-speed wireless, from best-effort to reservation-based protocols. The computing environment of the future promises to be even more heterogeneous.

MSHN seeks to take advantage of that heterogeneity. Some applications perform better on particular computing platforms, and some perform worse. Also, some computing platforms are busier than others at any one time. Given a set of applications and a set of computing resources, there exists an optimal assignment of resources to applications such that, overall, the highest Quality of Service is delivered to all applications. But finding that optimum can take a long time as the number of applications and computing resources increases. Fortunately, there are techniques for finding near-optimal solutions to this type of problem.

The problem is compounded, however, by the super-dynamic nature of computing environments. The load on computing and networking resources is constantly fluctuating. One computing resource may be completely available in the morning, then become much more utilized in the afternoon. Applications that are adaptive can adjust to these changing conditions and continue to provide useful output, but they have to know when to adapt. Mechanisms for affecting adaptation in adaptable applications and monitoring the fluctuations in resource availability are two of the issues being addressed by MSHN.

MSHN's primary challenges are to 1) accurately monitor resource availability, 2) accurately characterize and measure application resource requirements and 3) appropriately assign and re-assign computing resources to applications, adapting them as necessary.

Dissecting the architecture

A conceptual view of the MSHN architecture is shown in Figure 1. Everything above the operating system and to the right of the middleware is part of the design. It includes the

--continued on page 20

PROJECT NOTES

INTELLIGENCE AND THE CUBAN MISSILE CRISIS

Associate Professor **James J. Wirtz**
Department of National Security Affairs

Associate Professor **James J. Wirtz** recently contributed to a multi-year project to evaluate the role played by intelligence in the genesis, management and resolution of the 1962 Cuban Missile Crisis. The project, sponsored by the Woodrow Wilson International Center for Scholars, the Thomas J. Watson Institute for International Studies (Brown University), the George F. Kennan Institute and the University of Toronto, explored the role played by American, Soviet and Cuban intelligence communities in the events surrounding the “Missiles of October.” As the first comprehensive study of the role of intelligence in the crisis, the project, headed by James Blight of Brown University and David Welch of the University of Toronto, used Soviet archival material, evidence obtained from the testimony of former Cuban intelligence officers and the expert commentary of key U.S. participants in the crisis to create a documentary record. Professor Wirtz was tasked with developing a theoretical framework to facilitate comparative evaluation of the role of each of the intelligence communities in the Missile crisis. His chapter, “Organizing for Crisis Intelligence: Lessons from the Cuban Missile Crisis,” was initially presented at the Wilson Center, Washington, D.C., in September 1997. The entire project has been published as a special issue of the journal, *Intelligence and National Security* Vol. 13, No. 3, Autumn 1998, and as a separate volume, James G. Blight and David Welch (eds.) *Intelligence and the Cuban Missile Crisis*, (London: Frank Cass, 1998).

A CONCISE THEORY OF COMBAT

Senior Lecturer **Wayne Hughes, Jr.**
Department of Operations Research

A year ago, *A Concise Theory of Combat* was one of the first publications by the NPS Institute for Joint Warfare Analysis. Co-authored by Senior Lecturer **Wayne P. Hughes, Jr.** of the Department of Operations Research, along with Brigadier General Edmund DuBois USA (Retired), and Lawrence J. Low, both of the Stanford Research Institute until they retired, the publication is co-sponsored by The Military Conflict Institute (TMCI). TMCI is one of the few organizations with an international membership that fosters core research for a deeper understanding of warfare.

The purpose of the theory is to organize “what everyone knows” about combat in a coherent structure, based on six fundamental axioms and a handful of critical definitions. One of its aims is to respond to many operations analysts who complain of the lack of theoretical underpinning for warfare models—what Paul Davis and Don Blumenthal call “The Base of Sand Problem” in their landmark essay. In response, Hughes, DuBois, and Low frame the elements and dynamics of combat to embrace the roles of mind and morale as well as purely physical phenomena such as terrain, force numbers, and detection ranges.

The theory is merely descriptive of combat; the authors say prescriptive analysis (“how to win”) falls outside of their objective. They believe the efforts to create combat models with greater and greater physical fidelity now so much in evidence are leading up a blind alley. They acknowledge the difficulty of representing and measuring such factors as courage, fear, and the will to win. But the theory asserts that if operations analysts are unable or unwilling to deal with these cognitive factors, studies cannot move beyond a perspective that says causing casualties and destruction is the only noteworthy purpose of a battle.

The Naval Postgraduate School has been appointed Executive Agent to conceive, launch, catalyze and manage the External Acquisition Research Program for the Defense Acquisition University (DAU). This appointment follows nearly two years of active participation with DAU research planning, and results from NPS submitting a winning competitive proposal describing our plans for the program. The program goals include increasing the quality and quantity of scholarly research addressing topics of interest and relevance to the acquisition community (e.g., contracting, procurement, program management, systems engineering, logistics), and it targets leading researchers at top universities outside the DoD “sphere of influence.” Assistant Professor **Mark Nissen**, Department of Systems Management, is serving as the initial program manager. Information pertaining to this program is available via the web at <http://web.nps.navy.mil/~menissen/earp/earp.html>.

PROJECT NOTES

PERSPECTIVE VIEW AND LINE-OF-SIGHT SERVER

Research Assistant Professor Wolfgang Baer
Department of Computer Science

Under the sponsorship of the U.S. Army TEXCOM, Ft Hood, the development of a line-of-sight and perspective view server software package called PVNT has been completed. The package utilizes a one-meter terrain database to generate realistic battlefield images and line-of-sight calculations in real time. It will support operational test of helicopter-based weapons at Yuma in the spring of 1999.

A sample screen snapshot of the images generated is shown to the right. Two helicopters are seen flying over terrain at Fort Hunter Liggett, California. A trail appears in the lower right of the image. This feature is several meters wide and shows the level of detail achieved. Line-of-sight is calculated deterministically and can include background contrast data in order to generate detection probabilities.

A demonstration CD-ROM of executable code including a sample world wide database with 16-meter data at China Lake and one meter data at Fort Hunter Liggett has been prepared for distribution. The program executes on Win 95, 98 and NT platforms directly off the CD-ROM. The package can also be loaded on a local hard drive for faster execution. The demonstration program generates free flight perspective views in real-time on the NPS Quad Pentium 200 Mhz machine. It also displays a line-of-sight ground print on a map overview. The map scales from one meter to world size. This demonstration is offered to show that world wide one-meter metrically accurate terrain based applications are a reality in low cost PC platforms. For additional information or a copy of the package, contact baer@cs.nps.navy.mil



MSHN, continued from page 18

Scheduling Advisor (SA), the Resource Status Server (RSS), the Resource Requirements Database (RRD), the MSHN Daemon, the Load Emulator, and the Client Library. Although not labeled in the figure, the Client

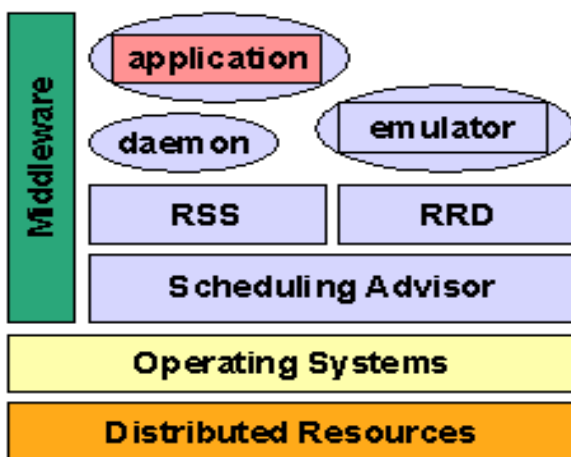


Figure1. Conceptual view of MSHN architecture.

Library is shown wrapped around the Load Emulator and the application.

MSHN components operate at the middleware level, allowing them to run on top of any operating system. They are able to run in a distributed manner across multiple computing resources. The MSHN design includes replication of MSHN components for scalability and fault-tolerance.

The MSHN Scheduling Advisor (SA) is based on concepts first implemented in SmartNet, a project developed at NRaD in San Diego. SmartNet was a heterogeneous high-performance computer scheduling and management framework serving the commander's perspective, rather than subordinate users. The MSHN Resource Status Server (RSS) component provides the SA with resource availability information and the MSHN Resource Requirements Database (RRD) component provides the SA with application parameters and formats (including the resource needs of the application). Upon receiving a schedule request from an MSHN-enabled

--continued on page 47

TECHNOLOGY TRANSFER

NPS TECHNOLOGY TRANSFER BUSINESS PLAN

The Technology Transfer Program at the Naval Postgraduate School was initiated in response to legislation passed to encourage the transfer of federally funded technologies to the private sector. The primary objectives of the Technology Transfer Program at NPS are to initiate partnerships with industry and/or academia, license existing technologies, and encourage and assist faculty and staff to transfer newly developed technologies to the private sector. Technology Transfer at NPS is served in various forms: Cooperative Research and Development Agreements, patents, and publications.

The faculty principal investigator has primarily driven NPS' past participation in the Technology Transfer Program. Networking between the scientists and engineers at NPS with their counterparts at other academic institutions and industry have forged the framework for the cooperative agreements which have been initiated in the past. Faculty research will remain the driver in the future for the establishment of Cooperative Research and Development Agreements, patents, and scholarly publications. To this end, the NPS' Technology Transfer Program will take advantage of the unique environment at NPS which is conducive to the development and organization of collaborative and consortia research initiatives. The primary components of the NPS Technology Transfer Program include:

- **Cooperative Research and Development Agreements:** CRADAs are a widely used mechanism which enables a government institution and a private company to work together to develop commercial products or processes from technology owned by the government. The number of agreements initiated and finalized by NPS has risen steadily in the last several years.
- **Work for Services:** Whereas this activity in itself does not allow for the transfer of technology, it does allow the industrial requestor to learn more of NPS's capabilities and can possibly lead to a follow-on relationship, i.e. CRADA.
- **Patents:** NPS faculty/students continue to file patent applications when their research reaches a stage which warrants the protection provided.
- **Publications:** Publication is one of the most basic venues for technology transfer. NPS faculty publish extensively in the refereed journals and other scholarly publications. NPS students are required to complete a thesis as part of their masters' degree.
- **Memoranda of Understanding/Agreement:** Whereas these agreements are with other DoD entities, they can

provide the vehicle by which the partnering DoD agencies can seek partnerships outside of DoD.

- **Consortia:** NPS is actively pursuing partnerships with other academic institutions within the same geographic location. The Monterey Bay Crescent Ocean Research Consortium, which is a confederation of several agencies (education, research, governmental, advocacy) around the Monterey Bay, is focused on the ocean sciences. NPS also participates in the Monterey Bay Education, Science and Technology (MBEST) Center, which is attempting to partner with local research organizations to more effectively implement technology transfer.

The Office of the Associate Provost and Dean of Research has responsibility for the NPS Technology Transfer Program. It is instrumental in liaisoning with entities outside of NPS for raising the awareness of the wide range of outstanding research being conducted at NPS. Functions which provide additional support to the NPS Technology Transfer Program include:

- **ORTA Representative:** The ORTA representative has primary responsibility for assisting faculty and their industrial partners with the means for initiating cooperative agreements. The ORTA representative also identifies and markets existing NPS technologies.
- **Office of General Council Representative:** The OGC representative at the Naval Postgraduate School reviews all Cooperative Research and Development Agreements, Memoranda of Understanding/Agreement, and facilitates the patent application process.
- **NPS Research Board:** The NPS Research Board is comprised of the Associate Chairs of Research from each of the academic departments and interdisciplinary groups and two representatives from the Faculty Counsel. One of the functions of the Board is to serve as the Invention Evaluation Board which reviews/prioritizes patent applications, and considers renewal of maintenance fees for existing patents. The Board is also instrumental in advising the Associate Provost and Dean of Research on policies governing the overall NPS Research Program.
- **SBIR Site:** NPS has recently become an SBIR site. As such, NPS faculty will be identifying potential SBIR topics and monitoring the progress of those awarded. The NPS Research Board ranks and approves topics submitted for consideration. The SBIR Program is another venue for increased interaction with industry and increases industry's awareness of NPS research and potential.

In FY98, the NPS Technology Transfer program continued to evolve. Potential partnerships and/or applications are continuously being explored.

STUDENT RESEARCH

A QUANTITATIVE INQUIRY INTO THE APPLICABILITY OF HYPERSPECTRAL IMAGING TECHNOLOGY AS AN AIRBORNE LITTORAL UNDER- SEA WARFARE (USW) SENSOR

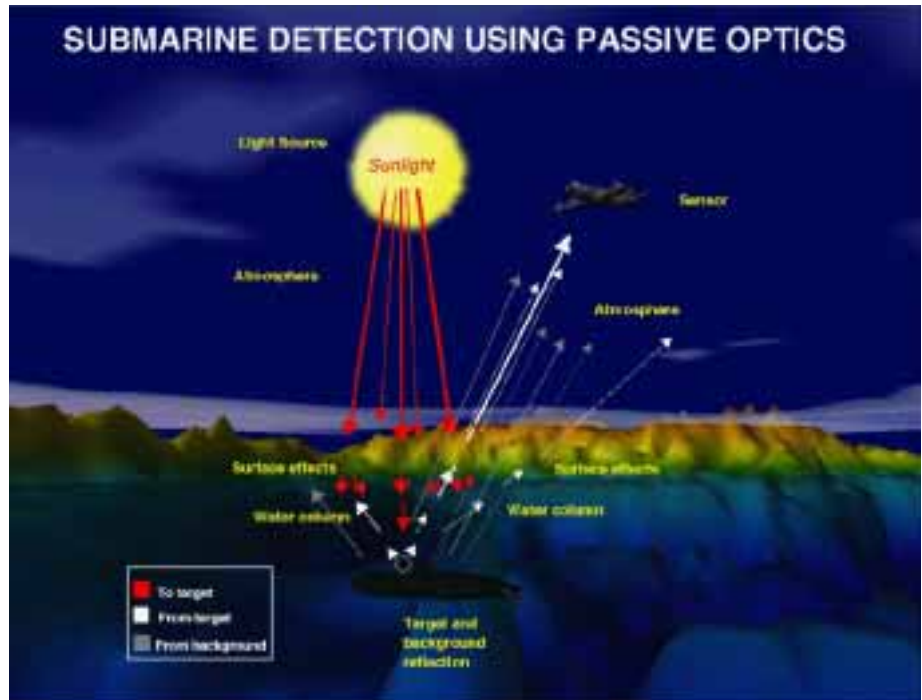
LT Jack Thomas, USN

Advisor: Professor Alan Washburn,
Department of Operations Research

For years, passive acoustics have been the primary means of detecting and locating submerged submarines. When submarines operate in a deep-water environment, acoustics are quite effective in this role. Unfortunately, today's Under-Sea Warfare (USW) forces are challenged by a threat that is likely to operate in noisy, near-shore, shallow-water environments. In addition, this threat is much more likely to be at or near the surface. These facts make traditional acoustic USW extremely challenging.

New technologies have been proposed to help counter this new threat effectively. Among them is the idea of using an airborne, passive Hyperspectral Imaging (HSI) sensor to measure small contrast differences in reflected sunlight to detect submarines. This new class of sensor is literally able to look into the water column and detect the differences in reflected light between the submarine and the surrounding waters.

There are currently several research programs involved in determining the suitability of HSI technology to littoral USW. Flight testing of these systems has yielded mixed



results indicating an incomplete understanding of environmental sensitivities and systemic limitations. Flight hours are expensive and hard to come by. What is needed is a method to accurately model the physical system that results in detectable amounts of energy at the HSI sensor. Figure 1 illustrates the physical system to be modeled.

A great deal of modeling has been done to describe the characteristics of light travel through the atmosphere and seawater. In addition, work has been done to synthesize the optical properties of submarines and sea surface conditions. These models have been incorporated to generate highly accurate predictions of contrast differences between a submarine and its surrounding environment.

--continued on page 23

The Office of Naval Research Naval Science Assistance Program (NSAP) provides on-the-spot technical assistance to the Joint and Naval operational commands. NSAP solves real operational problems in a rapid and inexpensive manner through the evaluation and insertion of mature technologies. NPS has established a relationship with NSAP to couple fleet/force issues into NPS thesis research.

Several students at NPS are currently being funded through the NSAP Program. **LT Jack Thomas, USN**, is one of them. He previously served as a P-3 TACCO (tactical coordinator) and mission commander in VP-9 at Barbers Point, HI, and more recently as the aide to the Deputy Commander-in-Chief of the U. S. Pacific Fleet (DCINC PACFLT). During that tour, he became interested in the various hyperspectral imaging research programs being conducted, and is now focusing his thesis research in that area.

LITTORAL USW SENSOR, *continued from page 22*

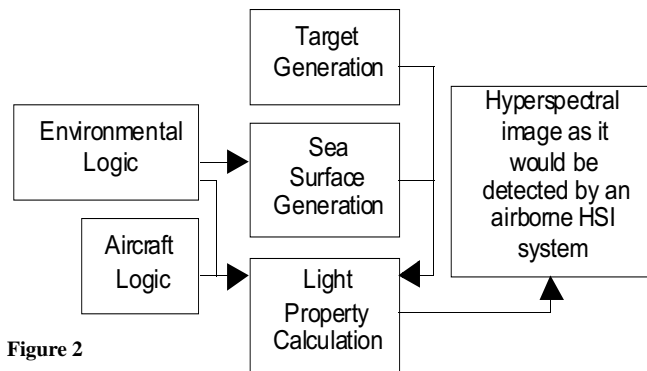


Figure 2

This thesis will fuse the current fixed-state model with temporal aircraft and environmental logic. This fusion, shown in figure 2, will yield an end-to-end, high fidelity simulation allowing accurate analysis of an HSI sensor's operation and environmental sensitivities. Figure 3 lists the physical parameters and environmental variables that

--continued on page 47

<i>Physical parameter</i>	<i>Environmental Variable</i>
Target Latitude/Longitude/Depth	Sky condition
Sensor	Sea surface conditions
Latitude/Longitude/Altitude	Living organism distribution in water column
Sun Azimuth and Elevation	Type and quantity of suspended solids in water column
Bottom Depth and composition	

Figure 3

PROCESS INNOVATION: ANALYSIS AND REDESIGN OF THE CALIFORNIA ARMY NATIONAL GUARD STATE EMERGENCY MOBILIZATION PROCESS

Capt Patrick F. McGuire, USMC, Capt Andrew J. Palan, USMC, and LT David A. White, USN
Masters of Science in Information Technology Management-September 1998

Advisors: Assistant Professor Mark E. Nissen, Department of Systems Management, and Assistant Professor Suresh Sridhar, Information Systems Academic Group

The California Army National Guard is responsible for providing emergency services in response to natural disaster, civil disobedience and other severe problems, as well as supplementing the U.S. Army on both the battlefield and operations other than war. In the case of emergency services, the Guard must respond very quickly to unpredictable events, such as earthquakes, floods and fires, yet operate effectively in a budget-constrained environment. This thesis investigates the Guard's Emergency Mobilization Process for innovation opportunities. The Guard's Emergency Mobilization Process is similar in many respects to mobilization processes employed by the Air Force, Army and Navy, and it requires the fast integration of both aviation and ground assets and personnel. Using a hybrid Davenport-Nissen reengineering methodology and knowledge systems for intelligent redesign support, the Emergency Mobilization Process is first modeled and analyzed to diagnose pathologies and

identify opportunities for quantum performance improvement. In the case of the Guard, this process is entirely sequential, suffers from substantial workflow friction and has inadequate information technology (IT) support for communication. Recommendations for redesign alternatives include three, increasingly-sophisticated but -risky options, which reflect process transformations based on a combination of IT, information-distribution, organizational-design and human-resource enablers of change. Process benchmarking and adaptation of best commercial practices (e.g., employed for oil-fire control in Kuwait) also played an important role in developing the redesigns. Interestingly, leaders at the Guard originally requested and sponsored a purely-technical thesis project oriented toward design and implementation of an intranet application. However, redesign analysis indicated process pathologies beyond the reach of IT solutions; hence the process and organization were redesigned to complement IT-enabled change. Estimates indicate the redesigned Emergency Mobilization Process can achieve a dramatic reduction in cycle time, and also significantly reduce cost, while maintaining or improving the current, exceptional level of service and quality. The Guard is interested in continued research along these lines to investigate other key enterprise processes. It is important to note the redesign methodology applies equally well to key Air Force, Army and Navy processes, and the redesign alternatives developed through this thesis appear to generalize directly to mobilization processes of the Services as well.

STUDENT RESEARCH

DESIGN, IMPLEMENTATION, AND TESTING OF MSHN'S RESOURCE MONITORING LIBRARY

CPT Matthew C. L. Schnaidt, USA

Master of Science in Computer Science-December 1998

Advisor: Assistant Professor Debra Hensgen and Senior Lecturer John Falby, Department of Computer Science

The Management System for Heterogeneous Networks (MSHN) requires the gathering of resource usage information of applications that run within the MSHN system and status information of the resources within the scope of the MSHN scheduler. The MSHN scheduler uses this information to make decisions. This thesis investigates one method of gathering the required information: a client library.

This research develops the mechanism and policy for the client library's resource monitoring role and carefully documents how applications can be easily linked with this client library. During run time the client library gathers information on an application's resource utilization by intercepting system calls and through the use of operating system functions. Resource information gathered includes total runtime, local and remote disk use, network use, memory use, CPU use, and time blocked waiting on user input.

The client library also determines end-to-end perceived status of the resources that the application uses. Specifically, this thesis develops a policy for passively gathering network performance characteristics, i.e., latency and throughput.

The per system call overhead added varied from less than 1% to 326%, with an average of 3% overhead added to the run-time of test programs.

EVALUATING SECURITY ASSISTANCE PROGRAMS: PERFORMANCE EVALUATION AND THE EXPANDED INTERNATIONAL MILITARY EDUCATION AND TRAINING (E-IMET) PROGRAM

Capt Todd R. Calhoun, USMC

Master of Science in Management-December 1998

Advisor: Professor Nancy Roberts, Department of Systems Management, and Associate Professor Francois Melese, Defense Resource Management Institute

In 1991 the International Military Education and Training (IMET) program was expanded to include training programs focusing on civilian control over the military, respect for human rights, and responsible defense resource management. In 1993 Congress institutionalized the federal government's commitment to performance measurement by signing into law the Government Performance and Results

STUDENT FELLOWSHIPS AWARDED BY SPACE AND NAVAL WARFARE SYSTEMS CENTER-SAN DIEGO

The Space and Naval Warfare Systems Center-San Diego (SSC-SD) sponsors a Research Fellowship Program at NPS. The program was instituted to promote SSC-SD's partnership with NPS, address SSC-SD's research focus areas, lay the groundwork for future technical and project management assignments, and foster long-term professional associations with SSC-SD's technical personnel and management.

Five NPS students were recently awarded fellowships. The award includes \$10,000 to support the student's research. The most recent awardees (listed with their research topic) are:

- **LT Raymond Tortorelli, USN**, Security of the TCP/IP Protocol in the Windows NT 5.0 Environment
- **LT Jung Y. Suh, USN**, Feasibility of Deployment of High Powered Microwave Application for Information Operations
- **LT Wayne F. Slocum, USN**, Evaluation of Low Cost Network Intrusion Detection Software for the Digital Battlefield
- **LT Jonathan Bartel, USN**, Investigation of Security Weaknesses of Common Network Routers and Firewalls for Information Operations
- **LT Glenn A. Barker, USN**, Integration of Active SIGINT and Decision-Making Tools into SI JMCIS

Act (GPRA). GPRA requires the Departments of State and Defense to demonstrate the results achieved by programs such as Expanded IMET (E-IMET). The purpose of this study is to address how the Defense Security Cooperation Agency (DSCA) can tackle the challenge of measuring the effectiveness of the E-IMET program. A spectrum of approaches exists to evaluate public programs and is anchored on one end by the "technically rational paradigm" and on the opposite end by the "politically rational paradigm." By organizing the security assistance objectives of key E-IMET stakeholders into a Global Hierarchy the researcher was able to link the E-IMET program to national level goals, creating an objective baseline from which to measure the performance of the program. Individual objectives hierarchies were then created for each E-IMET objective and performance indices were proposed to meet the requirements of the GPRA mandate.

STUDENT RESEARCH

DETERMINATION OF DIESEL ENGINE CYLINDER GAS TORQUES FROM SPEED FLUCTUATIONS WITH A HIGH-FIDELITY CRANKSHAFT TORSIONAL MODEL

LT William J. Swanson, USN

Master of Science in Mechanical Engineering and Mechanical Engineer-December 1998

Advisor: Associate Professor Knox T. Millsaps, Jr., Department of Mechanical Engineering

An experimental investigation was conducted to develop a method of predicting cylinder indicated torques in a reciprocating engine by measurement of crankshaft angular velocity fluctuations. Cylinder indicated pressures were measured for all three cylinders of a two-stroke Diesel engine with pressure transducers. Time-resolved angular position was measured at the crankshaft front and at the flywheel. A six degree-of-freedom torsional crankshaft model was developed. Two solution methods are described to solve the equations of motion: a time-marching ODE solver, and a Finite Element solution in the time domain. Using these methods with the measured cylinder torques, the angular positions are predicted and compared to measured angular positions for model calibration. An inverse solution method was developed to determine the cylinder indicated torques from the measured angular position at the crankshaft end-points. The method is theoretically demonstrated to be useful for explicit solutions for two-stroke engines up to three cylinders, and four-stroke engines up to four cylinders. Experimental results show that the method is useful in predicting cylinder indicated torques from angular velocity measurements.

LtCol Steve Baker, USAF, a 1997 PhD graduate of the Department of Operations Research, now serving as an assistant professor of operations research at the Air Force Academy, was recently honored for his dissertation research. He won an honorable mention for the George B. Dantzig Award, which is named for the inventor of the simplex method for linear programming, the most widely used optimization algorithm for the last fifty years. The Dantzig Award is given annually by the Institute for Operations Research and Management Science (INFORMS) for "the best PhD dissertation, in any area of operations research, that combines theory and practice." There were 42 nominees this year. The winner and runner-up are currently assistant professors at the University of Chicago and MIT, respectively. Baker, the only honorable mention, received a plaque and a check at the INFORMS

AMERICAN CULTURE, MILITARY SERVICES' CULTURES, AND MILITARY STRATEGY

LCDR Peter D. Haynes, USN

Master of Arts in National Security Affairs-Dec 1998

Advisors: Associate Professor James J. Wirtz and Associate Professor Daniel J. Moran, Department of National Security Affairs

The knowledge of one's culture is critical for success in statecraft and strategy. Yet, perhaps because it is so pervasive, the influence of one's own culture on strategy, defense preparation, and the conduct of war tends to escape notice. The influence of American culture on strategy, however, does not escape the notice of America's potential enemies. This thesis explores the American approach to strategy from a cultural perspective. It examines characteristics of American culture and the cultures of the four U.S. military services, which influence the U.S. strategy-making process. It explains how these characteristics formed and how they might influence American strategy. Unlike traditional explanations of the U.S. military cultures, such as Carl Builder's *The Masks of War*, this analysis examines the services' cultures from a more operational perspective. This thesis emphasizes the role the services' respective operating environments play in shaping their divergent perspectives on strategy, joint command structures, and doctrine. Cultural self-knowledge allows American strategists to recognize when aspects of American culture and the cultures of the services may make some strategies possible, desirable, or unimaginable. It allows American strategists to recognize when political leaders' goals and the services' strategies may be poorly matched.

Conference in Seattle on October 27, 1998.

LtCol Baker's dissertation, *A Cascade Approach for Staircase Linear Programs with an Application to Air Force Mobility Optimization*, was advised by Professor **Richard E. Rosenthal**, Chair of the Department of Operations Research. LtCol Baker's dissertation consists of theoretical work in large-scale linear programming, used in conjunction with a new optimization model of Air Force airlift assets in wartime. He developed this model jointly with Research Assistant Professor **Laura Williams**, Department of Operations Research, and former National Research Council Post-Doctoral Fellow David Morton (now at UT-Austin). It has been used by the Air Force to answer questions about aircraft fleet selection, airfield infrastructure investment, and airlift concepts of operation.

--continued on page 33

SHORT COURSES

CLASSIFIED ADVANCED TECHNOLOGY UPDATE SHORT COURSE

The Naval Postgraduate School will offer a Classified Advanced Technology Update Short Course, coordinated and hosted by Professor **Herschel H. Loomis**, Department of Electrical and Computer Engineering, and the NPS Cryptologic Chair Professor, **Vicente C. Garcia**, during the week of 8-12 March 1999. Approximately 80 government and industry personnel are expected to attend.

The Classified Advanced Technology Update is intended for TOP SECRET/SCI-cleared military and civilian technical personnel who are interested in refreshing and updating their knowledge in classified areas of advanced technology which support the mission of the Department of Defense. Course topics will include Cryptology, Information Operations, Overhead Reconnaissance, Digital Signal Processing, Navigation, Communications, Low Probability of Intercept and Geolocation.

TECHNOLOGY REVIEW AND UPDATE

The Naval Postgraduate School will offer the sixteenth Technology Review and Update Course for Technical Personnel the week of 26-30 April 1999. Professor **Rudolf Panholzer**, Dean of Science and Engineering and Chair of the Space Systems Academic Group, coordinates the course.

This course is at the unclassified level. Session presenters will be from both academia and industry. Sessions will cover:

- Information Warfare and Information Operations
- Electro-Optical and Infrared Systems
- Micro Electro-Mechanical Systems (MEMS)
- Optical Sensing Technology
- Military Satellite and Communications Technologies
- Satellite Communication Technologies and Trends
- Integrated Circuits
- Computational Intelligence

The course is intended for military and civilian technical personnel interested in refreshing and updating their knowledge in the areas listed above. The course provides an excellent overview and stresses the more practical aspects of the topics listed. For more information, see <http://www.sp.nps.navy.mil/trau99/trau99.html>.

RECENT RESULTS IN WARFIGHTING TECHNOLOGIES WORKSHOP '99

The Naval Postgraduate will offer the Recent Results in Warfighting Technologies '99 Workshop from 8-26 February 1999. This three-week course is offered by the NPS Center for Joint Services Electronic Warfare Simulation and Modeling and is intended for international military officers and technical research personnel who are interested in the technologies of command and control warfare (C2W). The course will cover:

- Tactical Operations
- Cruise Missile Technology and Ship Self Defense
- Unmanned Aerial Vehicle Technology
- Electronic Warfare Modeling and Simulation
- Advanced Receiver Technology
- C2W Architectures
- Laser and Radar Cross-Section Engineering
- Infrared and Electro-Optical Systems and Countermeasures
- Weapons Effects and Ultra-Wideband Sources and Their Effect

ENGINEERING APPROACHES FOR INFORMATION ASSURANCE: AN INTRODUCTION TO COMPUTER SECURITY

The NPS Center for Information Systems Security Studies and Research (CISR) conducted a weeklong short-course in December 1998. This was the first in a series of courses to be offered by CISR. The course was intended for military and civilian technical personnel with a need to understand the technical foundations of information assurance in systems of computers. The topics addressed included privacy concerns, data secrecy and integrity, security mechanisms, and factors affecting the secure use of computers. The course included an overview of cryptography, protocols, network security architectures, the effective use of high-confidence components for enforcement of security policy, database security and operational systems security. Special emphasis was placed on protecting sensitive and classified information in systems, enforcement of DoD and government information security policies, computer virus and malicious software concerns, and access control in computer systems.

NPS CISR plans to repeat this course via a distance learning connection to the Defense Information Systems Agency in March 1999.

MEETING ON DETECTION OF HIDDEN OBJECTS HELD AT NPS

Problems confronting the defense community can be difficult to solve because the solutions require input from many disciplines, technical as well as social sciences, in addition to sensitivity to differing service cultures. These topics were addressed during two parallel meetings held under the auspices of the International Advanced Studies Institute (IASI) and hosted by the NPS Institute for Joint Warfare Analysis during the week of 19-23 October 1998. Over 100 participants attended the sessions.

The session on the "Exploration of Subsurface Phenomena by Particle Scattering," considered microscopic detection at the atomic level. Topics covered included material science, atomic and solid state physics, and the science of thin films. Subjects ranged from x-ray studies of magnetic domains, ion beam characterization of oxide films to neutron reflectivity measurements. Among the participants were Dr. N. Q. Lam, editor of *Applied Physics Letters*, Dr. H. Dorsch, Directors of the Max Planck Institut for Metallforschung, Professor S. C. Moss, University of Houston, and Professor P. Pershan, Harvard University.

The parallel session on "Detection and Analysis of Subsurface Objects and Phenomena" considered the detection of macroscopic objects. Seismic detection techniques, detection of weapons and contraband materials, underwater sensing including the detection of mines and unexploded ordnance in marine environments, technologies for non-proliferation, treaty verification, safeguards and hazardous waste disposal, were the topics for this session. The presentations showed the importance of not only interdisciplinary understanding but also cross-disciplinary considerations where politics, history and sociology affect our ability to solve apparently technical problems. In his talk, "Fielding Technology Fast: The Kaho'olawe Model," James D. Putnam from the Naval Facilities Engineering Command at Pearl Harbor presented the challenges faced by the Navy in order to respond to national directives. Technologies common for responding to terrorist threats, ballistic missile proliferation, and airline security were related to each other so that practitioners in one field were able to learn applicable techniques from those in another field.

STRATEGIC STUDIES GROUP MEETS AT NPS

Members of the SSG met at NPS in November and participated in the following presentations:

- Electro-Optics and Fiber Optics, Professor **John Powers**, NPS
- Atmospheric Effects on Electro-Optics, Associate Professor **Don Walters**, NPS
- Information Warfare, **CAPT Jim Powell**, USN, NPS
- Small Surface Ship Survivability, Associate Professor **Chuck Calvano**, NPS
- Next Generation Guided Missiles and Seekers, Associate Professor **Robert Harney**, NPS
- Meteorological Capabilities for the Future Navy, Distinguished Professor **Russ Elsberry**, NPS
- Projected Fleet Utilization of Ocean Modeling in the Next Century, Professor **Bill Garwood**, NPS
- Bandwidth, Processors and Computer Devices in the 21st Century, Professor **Ted Lewis**, NPS
- Information Technology, Modeling and Analysis, Professor **Gordon Bradley** and Visiting Assistant Professor **Arnold Buss**, NPS
- Biology, Dr. Julie Theriot, Stanford University
- Directions in Modeling Virtual Environments and Simulation, Professor **Michael Zyda**, NPS

NPS continues to work closely with ADM Hogg and the SSG, as well as VADM Cebrowski and the new Naval Warfare Development Command on problems of area denial and the acquisition of concealed and mobile targets.

In 1995 the Chief of Naval Operations with the assistance of N00K and the CNO Executive Panel developed and assigned his Strategic Studies Group (SSG) a new mission. Under the leadership of ADM James Hogg, USN, Ret., the SSG has been examining the future operational, technical, and political environment for Naval Systems and has sought to identify opportunities for maintaining the U.S. Navy as the world's foremost naval force well into the next century. To this end a group of associate fellows were selected from NPS students and the Naval War College to participate with the SSG Fellows in conceptual studies to find effective and innovative options.

FACULTY NEWS

AERONAUTICS AND ASTRONAUTICS

M.S. Chandrasekhara, M.C. Wilder, **L.W. Carr**, "Unsteady Stall Control Using Dynamically Deforming Airfoils," *AIAA Journal*, Vol. 36, No. 10, pp. 1792-1800, October 1998.

M.S. Chandrasekhara, M.C. Wilder, **L.W. Carr**, "Compressible Dynamic Stall Control Using a Shape-Adaptive Airfoil," AIAA Paper 99-0650, 37th Aerospace Sciences Meeting, Reno, NV, 11-14 January 1999.

S.K. Hebbar, E. Enochs, **M.F. Platzer**, "A Subscale LDV Study of the Flowfield Near the Wingtip of a Hovering STOVL Aircraft," AIAA Paper 99-0905, 37th Aerospace Sciences Meeting, Reno, NV, 11-14 January 1999.

K.D. Jones and **M.F. Platzer**, "An Experimental and Numerical Investigation of Flapping Wing Propulsion," AIAA Paper 99-0995, 37th Aerospace Sciences Meeting, Reno, NV, 11-14 January 1999.

I.H. Tuncer and **M.F. Platzer**, "A Computational Study of the Flow Separation Characteristics and Wake Profiles Behind a Flapping Airfoil," AIAA Paper 99-0648, 37th Aerospace Sciences Meeting, Reno, NV, 11-14 January 1999.

S. Weber, **K.D. Jones**, J.A. Ekaterinaris, and **M.F. Platzer**, "Transonic Flutter Computations for a Supercritical Wing," AIAA Paper 99-0798, 37th Aerospace Sciences Meeting, Reno, NV, 11-14 January 1999.

Silva, S., **Brophy**, C.M., **Netzer**, D. W., "Measurement of Soot in Oxygen/Kerosene Exhaust Plumes," 24th JANNAF EPTS, Kennedy Space Center, FL, 9-13, November 1998.

Nickerson G.R., Johnson C.W., **Brophy C.M.**, "Prediction of Soot

Produced in Kerosene Fueled Rocket Engines," 35th JANNAF Combustion Subcommittee, Tucson, AZ, 7-11 December 1998.

COMPUTER SCIENCE

C.E. Irvine, J.P. Anderson, J. Hackerson, and D. Robb, "High Assurance Multilevel Services for Off-the-Shelf Workstation Applications," *Proceedings of the National Information Systems Security Conference*, Crystal City, VA, pp. 421-431, October 1998.

C.E. Irvine, S.K. Chin, and D. Frincke, "Integrating Security into the Curriculum," *IEEE Computer*, Vol. 31, No. 12, pp. 25-30, December 1998.

C.E. Irvine, "Do Hack/Attack Exercises Belong in the Classroom?" National Information Systems Security Conference: Panel on Computer Security Education, Crystal City, VA, October 1998.

R.F. Wright, D.J. Shifflet, and **C.E. Irvine**, "Security for a Virtual Heterogeneous Machine," *Proceedings of the Twelfth Computer Security Applications Conference*, Scottsdale, AZ, December 1998.

Prof. **G. Xie** served as the publicity chair for the Sixth IEEE International Conference on Network Protocols and chaired a technical session on Congestion Control, Austin, TX, 15-16 October 1998. Prof. **Xie** also co-organized and chaired a technical session sponsored by IEEE Technical Committee on Computer Communications at MILCOM '98, Boston, MA, 12-19 October 1998.

On the 29th of September through the 1st of October, Prof. **M. Zyda** attended meetings of the National Research Council's Committee on Advanced Engineering Environments (NRC AEE) held at NASA AMES Research Center, Moffett Field,

California. Prof. **M. Zyda** is a member of the NRC AEE committee, his third NRC study. The purpose of that committee is to advise the Director of NASA on how space and aeronautic systems of the future should be engineered. The Phase I report of the committee will be completed by May of 1999, with a more detailed Phase II study already planned through the year 2001.

Prof. **M. Zyda** gave a presentation entitled, "Games on the 'Net,'" at the Munchner Kreis Congress on the Internet of Tomorrow, European Patent Office, Munich, Germany, 19 November 1998. His presentation described what interactive games will look like on the Internet of the Future and detailed the technology needed to develop such games.

Prof. **Zyda** participated as a member of the Board of Visitors to the Office of Naval Research, Arlington, VA, 9 July 1998. As part of that Board, Prof. **Zyda** reviewed the Cognitive and Neural Sciences Division's (Code 342) Programs. Reviews of ONR programs by the Board of Visitors are used as an outside, unbiased look at directions proposed by ONR.

ELECTRICAL AND COMPUTER ENGINEERING

J. Butler, "On the Properties of Multiple-Valued Functions that are Symmetric in Both Variable Values and Labels," 28th International Symposium on Multiple-Valued Logic, Fukuoka, Japan, May 1998.

Prof. **J. Butler** received IEEE Computer Society's Certificate of Appreciation for contributions of the highest standard while serving as Vice-Chair of the 1998 Fellow Evaluation Committee.

-- continued on page 29

-- continued from page 28

T. Conka, **R. Hippenstiel**, and **T. Ha**, "Performance Analysis of DPSK Using Post-Detection Selection Combining Over a Rayleigh Fading Channel," 32nd Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, 1-3 November 1998.

R. Hippenstiel, Technical Area Track Chair and Session Chair for the 32nd Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, 1-3 November 1998.

C. Ong, **R. Hippenstiel**, and **T. Ha**, "Performance Analysis of DPSK Signals with Selection Combining and Convolutional Coding on a Rayleigh Fading Channel", 3rd International Symposium on Multi-Dimensional Mobile Communications, SRI International, Menlo Park, CA, 21-22 September 1998.

R. Janaswamy and J. B. Andersen, "Path Loss Predictions in Urban Areas with Irregular Terrain Topography," *Wireless Personal Communications*, January 1999.

D. Jenn, **P. Pace**, and **J. P. Powers**, "High-Resolution Acoustic Arrays Using Optimum Symmetrical-Number-System Processing," 24th International Symposium on Acoustical Imaging, Santa Barbara, CA, September 1998. Prof. **Powers** also chaired a session on Biomedical Applications at this conference.

P.E. Pace and G.D. Burton, "Anti-Ship Cruise Missiles: Technology, Simulation and Ship Self-Defense," *Journal of Electronic Defense*, Vol. 21, No. 11, pp. 51-56, November 1998.

R.J. Pieper and A.D. Kraus, "Cold Plates with Asymmetric Heat Loading," *International Journal of Microelectronics Packaging*, Vol. 1, pp. 115-129, 1998.

N. Sarkar, **X. Yun**, and Randy Ellis, "Live-Constraint-Based Control for Contact Transitions," *IEEE Transactions on Robotics and Automation*, Vol. 14, No. 5, pp. 743-754, October 1998.

T.R. Weatherford, G. David, T. Yun, M. Crites, J.F. Whitaker, K. Jobe, E.J. Ledbetter, S. Meyer, M. Bustamante, S. Thomas III, and E. Elliott, "In-Situ Picosecond Measurements of InP and GaAs Ics Utilizing Photoconductive Sampling Probes," *Proceedings for the 1998 EIA/IEEE GaAs Reliability Workshop*, Atlanta, GA, 1 November 1998.

MECHANICAL ENGINEERING

F. Novak and **T. Sarpkaya**, "Vortex Breakdown at High Reynolds Numbers," American Institute of Aeronautics and Astronautics (AIAA), Reno, NV, 11-15 Jan 99.

T. Sarpkaya, "A New Model for Vortex Decay in the Atmosphere," American Institute of Aeronautics and Astronautics (AIAA), Reno, NV, 11-15 Jan 99.

M. Saunders, **E.S.K. Menon**, D.J.

Chisholm, and **A.G. Fox**, "Extracting Chemical Information from Energy-Dispersive X-Ray Spectra by Multivariate Statistical Analysis," *Proceedings of Microscopy and Microanalysis* 1998, edited by G.W. Bailey, K.B. Alexander, W.G. Jerome, M.G. Bond and J.J. McCarthy; publisher Springer-Verlag, NY, 204, 12-16 July 1998.

NATIONAL SECURITY AFFAIRS

J. J. Wirtz, R. Harknett, and T.V. Paul (eds), "The Absolute Weapon Revisited: Nuclear Arms and the Emerging International Order," University of Michigan Press, 1998.

J.J. Wirtz, "Organizing for Crisis Intelligence: Lessons from the Cuban Missile Crisis," *Intelligence and National Security*, Vol. 13, No. 3 Autumn 1998.

J.J. Wirtz, "Organizing for Crisis Intelligence: Lessons from the Cuban Missile Crisis," James G. Blight and David Welch (eds), *Intelligence and the Cuban Missile Crisis* (London: Frank Cass, 1998).

J.J. Wirtz, "Review of Scott

-- continued on page 30

The recent book co-authored (with Eden Naby) by **Ralph H. Magnus** of the Department of National Security Affairs, *Afghanistan: Mullah, Marx and Mujahid*, Boulder: Westview Press, 1998, has been selected as an "Outstanding Academic Book" for 1998 by the editors of CHOICE. CHOICE is the journal of the Association of College and Research Libraries of the American Library Association. It reviews over 6,000 titles in all disciplines annually and selects approximately ten percent as Outstanding Academic Books. The criteria applied by the editors to the reviewed titles for this award is:

- overall excellence in presentation and scholarship
- importance relative to other literature in the field
- distinction as a first treatment of given subject in book or electronic form
- originality or uniqueness of treatment
- value to undergraduate students
- importance in building undergraduate library collections

-- continued from page 29

Sigmund Gartner's Strategic Assessment in War," *American Political Science Review*, Vol. 92, No. 2, December 1988.

J.J. Wirtz, "Counterproliferation, Conventional Counterforce, and Nuclear War," Third Pan-European International Relations Conference and Joint Meeting with the International Studies Association, Wirtschaftsuniversitat, Vienna, Austria, 16-19 September 1998.

Prof. **J. Wirtz** served as a Program Co-Chair, 1998 ISSS Annual Meeting, Monterey, CA, 6-7 November 1998. Prof. **J. Wirtz** also served as a Program Chair, International Security and Arms Control Section, American Political Science Association Annual Convention, Boston, MA, September 1998.

OCEANOGRAPHY

M.L. Batteen, N.-J. Huang, "Effect of Salinity on Density in the Leeuwin Current System," *Journal of Geophysical Research*, 103, 24, 693-24, 721, 1998.

M.L. Batteen and C.L. Butler, "Modeling Studies of the Leeuwin Current Off Western and Southern Australia," *Journal of Physical Oceanography*, 24, 2199-2221, 1998.

P.C. Chu, Y.C. Chen, S.H. Lu, "Temporal and Spatial Variabilities of Japan Sea Surface Temperature and Atmospheric Forcings," *Journal of Oceanography*, 54, 273-384, 1998.

P.C. Chu, S.H. Lu, and Y.C. Chen, "Wind-Driven South China Sea Deep Basin Warm-Core/Cool-Core Eddies," *Journal of Oceanography*, 54, 347-360, 1998.

P.C. Chu, C.W. Fan, C.J. Lozano, and J. Kerling, "An AXBT Survey of the South China Sea," *Journal of*

Geophysical Research, 103, 21637-21652, 1998.

P.C. Chu, S.H. Lu, and W.T. Liu, "Uncertainty of the South China Sea Prediction Using NSCAT and NCEP Winds During Tropical Storm Ernie 1996," *Journal of Geophysical Research*, 1998.

P.C. Chu, "Two Kinds of Predictability in Lorenz System," *Journal of the Atmospheric Sciences*, 1998.

P.C. Chu and N.L. Edmons, "A Three-Dimensional Numerical Simulation of the South China Sea Circulation and Thermohaline Structure," *Chinese Journal of Atmospheric Sciences*, 1998.

P.C. Chu and C.W. Fan, "A Non-Uniform Three-Point Combined Compact Difference Scheme," *Journal of Computational Physics*, 1998.

P.C. Chu, "High Accurate Difference Schemes for Ocean Models," International SPENISCRUMISEOM Users' Group Workshop, University of California at Davis, Davis, CA, 28-31 October 1998.

P.C. Chu and J.M. Veneziano, "A Numerical Simulation of the South China Sea Response to Tropical Cyclone Ernie 1996," 23rd Conference on Hurricanes and Tropical Meteorology, American Meteorological Society, Dallas, TX, 10-15 January 1999.

P.C. Chu and Q.Q. Wang, "Beaufort/Chukchi Sea Thermohaline Structure," 5th Conference on Polar Meteorology and Oceanography, American Meteorological Society, Dallas, TX, 10-15 January 1999.

P.C. Chu, S.H. Lu, and Y.C. Chen, "Two Kinds of Predictability," Second Hayes Symposium on Seasonal to Interannual Climate Variability-The 1997/1998 ENSO Cycle, American Meteorological Society, Dallas, TX, 10-15 January 1999.

P.C. Chu, "Multifractal Analysis of Ocean Mixed Layer Near Norwegian Coast," 13th Symposium on Boundary Layers and Turbulence, American Meteorological Society, Dallas, TX, 10-15 January 1999.

P.C. Chu and H. Liu, "Seasonal and Interannual Variabilities of the World Ocean Thermal Structure," 10th Symposium on Global Change Studies, American Meteorological Society, Dallas, TX, 10-15 January 1999.

P.C. Chu, S.H. Lu, and Y.C. Chen, "Circulations and Thermohaline Structures of the Japan/East Sea (JES) and Adjacent Seas Simulated by a Nested Basin/Coastal Model," International Symposium on Circulation Research of the East Asian Marginal Seas, Fukuoka, Japan, 25-29 January 1999.

P.C. Chu, Y.C. Chen, and S.H. Lu, "Japan/East Sea (JES) Polar Front Meandering and Eddy Shedding Detected from an Airborne Expandable Bathythermograph Survey, May 1995," International Symposium on Circulation Research of the East Asian Marginal Seas, Fukuoka, Japan, 25-29 January 1999.

Coale, K. H., Johnson, K. S., Fitzwater, S. E., Blain, S. P. G., **T. P. Stanton**, and Coley T. L., "IronEx I, An in Situ Iron-Enrichment Experiment: Experimental Design, Implementation and Results," *Deep-Sea Research II*, 45, 919-946, 1998.

A.F.G. Faria, **E. B. Thornton**, C. Soares, **T. P. Stanton**, C. V. Soares, and T. C. Lippmann, "Vertical Profiles of Longshore Currents and Related Bed Shear Stress and Bottom Roughness," *Journal of Geophysical Research*, V103, C2, 3217-3232, 1998.

C.S. Law, A. J. Watson, M. I. Liddicoat, and **T. P. Stanton**, "Sulphur

-- continued on page 31

-- continued from page 30

Hexafluoride as a Tracer Os Bio-geochemical and Physical Processes in an Open Iron Fertilization Experiment," *Deep-Sea Research II*, 45, 977-994, 1998.

L.N. Ly and P. Luong, "Numerical Grids Used in a Coastal Ocean Model with Breaking Wave Effects," *Computational and Applied Mathematics*, 1998.

L.N. Ly and L. Jiang, "Horizontal Pressure Gradient Errors of the Monterey Bay Sigma Coordinate Ocean Model with Various Grids," *Journal of Oceanography*, 1998.

L.N. Ly and **R.W. Garwood, Jr.**, "On Breaking Wave-Enhanced Turbulence in the Oceanic Surface Boundary Layer," *AMS Thirteen International Symposium on Boundary Layers and Turbulence Proceedings*, 1998.

L.N. Ly, P. Luong, and **J. D. Paduan**, "Variable-Resolution 3-D Circulation Model for the Monterey Bay Region and its Summer Simulations," AGU Fall Meeting, San Francisco, CA, December 1998.

J. McClean, "Global Ocean POP Simulations and Data Comparisons," Climate Change Prediction Program Meeting, Phoenix, AZ, 12-14 October 1998.

J. McClean, "A High Resolution Fully Global Ocean Model Forced with Daily ECMWF Wind Stresses, Heat, and Freshwater, Fluxes for 1979-1997," *Eos Transactions*, American Geophysical Union, Vol. 79, No. 45, 10 November 1998.

M.G. McPhee, **P. Stanton**, J. H. Morison, and D. G. Martinson, "Freshening of the Upper Ocean in the Arctic: Is Perennial Sea Ice Disappearing?," *Geophysical Research Letter*, 25, 1729-1732.

E.T. Petruncio, **L.K. Rosenfeld**,

and **J.D. Paduan**, "Observations of the Internal Tide in Monterey Canyon," *Journal of Physical Oceanography*, 28, 1873-1903.

T.P. Stanton and L. Ostrovsky, "Observations of Highly Nonlinear, Tidally Forced Solitons Over the Continental Shelf," *Geophysical Research Letter*, Vol. 25, No. 14, 2695, 2698, 1998.

T.P. Stanton, C. S. Law, and A. J. Watson, "Physical Evolution of the IRONEX-1 Open Ocean Tracer Patch," *Deep-Sea Research II*, 45, 947-976, 1998.

OPERATIONS RESEARCH

T. Lucas, "The Warfighting Experiment Analytical Process-Where Do We Go from Here?" U.S. Army Conference on Applied Statistics (ACAS), Las Cruces, NM, 21 October 1998.

M.J. Sinai, T.L. Ooi, and Z.J. He, "Terrain Influences the Accurate Judgement of Distance," *Nature*, 395, 497-500, 1998.

SYSTEMS MANAGEMENT

J. Barrios-Choplin, "Factors Leading to Unsatisfactory Participation in the U.S. Army Reserve," Annual Army Operations Research Seminar, Fort Lee, VA, October 1998.

M.G. Ceruti and **M.N. Kamel**,

"Heuristics-Based Algorithm for Identifying and Resolving Semantic Heterogeneity in Command and Control Federated Database Systems," *Proceedings of the IEEE Knowledge and Data Engineering Exchange Workshop*, Taipei, Taiwan, November 1998.

D. Dolk, "Metric-Based Model Management," presented at the University of Aachen, Germany, 17 September 1998.

D. Dolk, "Modeling in the Data Warehouse Era," keynote address delivered at the IFIP 7.6 Working Group Conference, Laxenburg, Austria, 21-23 September 1998.

D. Dolk, "Metrics-Based Decision Support," IIASA JISR Conference, Laxenburg, Austria, 24-26 September 1998.

D. Eaton, "A New Strategy: Cultural Change for Better Logistics by the 21st Century," NASA Acquisition, Use and Disposal Conference, San Antonio, TX, 16 November 1998.

K.J. Euske, N. Frause, T. Peck, B. Rosenstiel, and Steve Schreck, "Service Process Measurement: Breaking the Code," The CAM-I Service Process Interest Group, Bedford, TX, p. 105.

Prof. **J. Fremgen** is serving as a member of the American Accounting

-- continued on page 32

An article by Associate Professor **Robert F. Dell**, Department of Operations Research, entitled "Optimizing Army Base Realignment and Closure," has been selected as the cover feature of the international journal INTER-FACES, November, 1998. The paper recounts how Professor Dell and a number of his students have helped the Army decide how to schedule the BRAC95 expenditure of about \$2 billion for 29 base closures and 11 base realignments. This work has saved the Army \$360 million. Perhaps more important, Dell's optimization-based decision support has provided a reliable foundation for a host of analyses and briefings delivered to DoD, Congress, and the President.

-- continued from page 31

Association's Outstanding Accounting Educator Award Committee for 1998-1999.

K. Gue, "Locating Facilities that Compete and Cooperate," *INFORMS Conference*, Seattle, WA.

G. Hildebrandt, "The Use of Performance Incentives in DoD Contracting," *Acquisition Review Quarterly*, Vol. 5, No. 2, pp. 217-233, (Spring 1998, Special Issue on Managing Radical Change).

S.P. Hocevar and **W.E. Owen**, "Team-Based Redesign as a Large-Scale Change: Applying Theory to the Implementation of Integrated Product Teams," *Acquisition Review Quarterly*, Vol. 5, No. 2, pp. 147-166, (Spring 1998, Special Issue on Managing Radical Change).

M. Kamel, "Migrating Legacy Systems and Database," *Proceedings of the Federal Database Colloquium DBASE '98*, San Diego, CA, September 1998.

K. Kang and R.J. Roland, "Military Simulation," *Handbook of Simulation*, J. Banks, ed., John Wiley & Sons, pp. 645-658.

Prof. **K. Kang** was selected to be the Program Chair for the Winter Simulation Conference in the year 2000 that will be held in Orlando, Florida. The Winter Simulation Conference is the largest international simulation conference.

K. Kang, K.R. Gue, and **D.R. Eaton**, "Cycle Time Reduction for Naval Aviation Logistics," *Proceedings of 1998 Winter Simulation Conference*, 1998.

M. Nissen, "An Intelligent Agent for Web-Based Process Redesign," *Hawaii International Conference on System Sciences*, Maui, HI, 5-8 January 1999.

M. Nissen was an invited speaker at the Applied Technology in Business Conference on Managing Information Technologies, Auburn Hills, MI, 1-3 October 1998. His presentation entitled "Intelligent Acquisition Agents" was received enthusiastically by the audience of industry executives and academics.

M. Nissen, "Intelligent Contracting Agents," 11th Annual Conference for Contract Management Educators, Naval Postgraduate School, 29-30 October 1998.

M. Nissen, "Acquisition Research: Questions and Ideas," 11th Annual Conference for Contract Management Educators, Naval Postgraduate School, 29-30 October 1998.

M. Nissen, "An Intelligent Agent for Web-based Process Redesign," *Proceedings HICSS-32*, Maui, HI (1999).

M. Nissen, "Alpha Contracting JSOW Style," *National Contract Management Journal*, 29:1, pp.15-32, 1998.

M. Nissen, K. Snider and **D. Lamm**, "Managing Radical Change in Acquisition," *Acquisition Review Quarterly*, Vol. 5, No. 2, pp.89-106, 1998, (Spring 1998, Special Issue on Managing Radical Change).

N. Roberts, "Radical Change by Entrepreneurial Design," *Acquisition Review Quarterly*, Vol. 5, No. 2, pp. 107-127, (Spring 1998, Special Issue on Managing Radical change).

N.F. Schneidewind, et al., "Roundtable; Weighing in on Standards," *IEEE Software*, Vol. 15, No. 6, pp. 92-102, November/December 1998.

N.F. Schneidewind, "Empirical Studies of Software Maintenance: A Report from WESS '97, Working Group 1: Defect Detection and Analy-

sis," *Empirical Software Engineering*, Vol. 3, No. 3, Kluwer Academic Publishers, pp. 300-301, September 1998.

N.F. Schneidewind, "How to Evaluate Legacy System Maintenance," *Nikkei Computer Books*, Nikkei Business Publications, Inc., 2-1-1 Hirakawacho, Chiyoda-Ku, Tokyo 102 Japan, pp. 232-240, 1998.

N. F. Schneidewind, "An Integrated Process and Product Model," *Proceedings of the International Metrics Symposium*, Bethesda, MD, pp. 224-234, 20-21 November 1998.

N.F. Schneidewind, "Methods for Assessing COTS Reliability, Maintainability, and Availability," *Proceedings of the International Conference on Software Maintenance*, Bethesda, MD, pp. 224-225, 16-20 November 1998.

N.F. Schneidewind, "How Can Changes in the Functionality of Maintained Systems be Measured?" Third Annual Workshop on Empirical Studies of Software Maintenance, WESS '98, Bethesda, MD, pp. 27-28, 16 November 1998.

N. F. Schneidewind, "Issues in the Next Generation of Dependability Standards," *Proceedings of the International Symposium on Software Reliability Engineering*, Paderborn, Germany, pp. 101-102, 4-7 November 1998.

N.F. Schneidewind, "Integration of Software Process and Product Measurement and Models," *Stan Ackerman Institute Symposium on Software Technology*, Eindhoven University of Technology, Eindhoven, The Netherlands, 6 November 1998.

N.F. Schneidewind, "Considering Risk in Software Reliability Predictions: A Space Shuttle Example,"

-- continued on page 33

-- continued from page 32

NASA - West Virginia University Workshop on Risk Management, Farmington, PA, 26 October 1998.

N.F. Schneidewind, "Measuring and Evaluating the Development and Maintenance Process Using Reliability, Risk, and Test Metrics," International Conference on Software Maintenance, Bethesda, MD, 56 pages, 17 November 1998.

K. F. Snider, "Living Pragmatism: The Case of Mary Parker Follett," *Administrative Theory and Praxis*, 20(3): 274-286.

J. Suchan and Alice Crawford, "Utilizing Telelearning as Strategic Media Choice to Enhance Executive Development and Affect Organizational Perspective," in D.A. Schreiber and Z.L. Berge (Eds.), *Distance Training: How Innovative Organizations are Using Technology to Maximize Learning and Meet Business Objectives*, San Francisco, CA, Jossey-Bass, pp. 369-390, 1998.

G. Thomas and M. Zak, "Drawing on our Strengths: Teaching Narrative in Field Work Projects," Association for Business Communication Annual Convention, 11 November 1998.

G. Thomas, "Strategic Issues for Executive Briefings: A Case Analysis," Association for Business Communication Annual Convention, 11 November 1998.

UNDERSEA WARFARE

J.S. Breemer, "Technological Change and the New Calculus of War: The United States Builds a New Navy," *The Politics of Strategic Adjustment: Ideas, Institutions, and Interests*, New York: Columbia University Press, pp. 213-32, 1999.

J.S. Breemer, "Sea Power in the New Century," *Sea Power in the New*

Professor **James Eagle**, Chair of the Undersea Warfare Academic Group, and Professor **Thomas Muir**, Chair of Mine Warfare, served on the CNO N-85 sponsored Mine Warfare Technology Team which recently met in November. The Mine Warfare Technology Team is a 20-member panel with a core membership from N-85, ONR, PEO-Mine Warfare, DARPA, COMMINEWARCOM, MARCORSYSCOM, and the Coastal Systems Station. NPS was asked to join as an associate member. The panel meets about four times a year. The November meeting involved the evaluation of presentations from industry on mine warfare technologies.

Century: Maritime Operations in the Asia-Pacific Beyond 2000, Canberra: Australian Defence Studies Centre, pp. 3-13, 1998.

J.S. Breemer, "Security in Northern Waters: A New Nordic Balance?," *Multinational Naval Cooperation and Foreign Policy into the 21st Century*, Aldershot: Ashgate, pp. 220-32, 1998.

DEFENSE RESOURCE MANAGEMENT INSTITUTE

R.E. Boynton and L. Vaughan, "Defining Organizational Measures for Naval Aviation Engineering Service Unit," NPS Report 64-98-001, September 1998.

J.C. Felli chaired "Decision Analysis and Managerial Perceptions," in the Decision Analysis track at the Fall INFORMS Conference in Seattle, Washington. In the session, he also presented a paper entitled "Rethinking Project Selection at the Monterey Bay Aquarium" with Randall E. Kochevar.

J.C. Felli and G.B. Hazen, "A Bayesian Approach to Sensitivity Analysis," *Electronic Health Economic Letters*, 2(4): 14-21.

Prof. **P.C. Frederiksen** attended the "Defense Resources Management Seminar" in Brasov, Romania, 14-15 December 1998. He was a moderator for the session on the "Integrated Concept of Resource Management," and also briefed the conference during

the session on "Education and Training in Resource Management."

N. Webb, "Relationship Between Nonprofit Organizations: A Stakeholder Perspective," Association for Research on Nonprofit Organizations and Voluntary Action, Seattle, WA, November 1998. **N. Webb** was also the committee chair for the 1998 Outstanding Dissertation in Nonprofit Research Award.

STUDENT RESEARCH

continued from page 23

Professors Rosenthal, Williams and Morton, and their students who, in addition to LtCol Baker include Major Lim Teo Weng of the Singapore Air Force, LTs David Fuller and David Goggins of the USN, LTJGs Ayhan Toy and Yasin Turker of the Turkish Navy, have been working on a research project sponsored by the Air Force, Optimization Models for Airlift Mobility, continuously since 1993. This project was a featured news story on the official Air Force web site. [See "Navy professor helps Air Force contingency planning", www.af.mil/news/Jan1998/n19980121_980083.html, released Jan 22, 1998.] The awarding of the Military Operations Research Society's David Rist Prize to Rosenthal, Morton and Lim in 1997 has also recognized the work.

FEATURED PROJECT

FIBER LASER, *continued from page 3*

amplifier has a lower saturated output power [4,5]. For the NPS laser, an erbium-doped fiber amplifier pumped by 200 mW of optical power from two 980-nm pump laser diodes is used to replace the erbium/ytterbium (Er/Yb) co-doped fiber amplifier in the original NRL design. The use of laser diodes instead of a solid-state pump laser results in a reduced saturated output power from the amplifier of 51 mW (*one-fourth* the power of the NRL amplifier), as well as a reduced weight and volume. Although the reduction in fiber amplifier power results in a wider linewidth, a lower peak power output, and not as much pulse compression, the decreased power requirement makes the device attractive for small, mobile platforms where power is at a premium. The ability of this lower power design to directly sample antenna signals was the subject of our investigation and the results are discussed in the sections below.

Laser Performance Measurements

Measuring the operating properties of a subpicosecond pulse with jitter of a few 10s of femtoseconds is a challenge, since no electronic instrumentation exists with the

required terahertz bandwidth. The wavelength, spectral linewidth, and average optical power of our laser were measured using an optical spectrum analyzer and optical multimeter. The laser pulsewidth was measured using an optical autocorrelator. The noise and jitter were computed from the output traces of a wideband microwave spectrum analyzer. Computer acquisition of the measured data was a major contributor to data recording and analysis for this laser and was especially helpful in measuring the various noise components. The spectrum analyzer measured 600 data points as set from the front panel of the equipment. The data points were extracted from the analyzer's memory using LabView 4.0 software, plotted to the computer display, and saved to the computer hard disk. The recorded data were plotted using MATLAB 5.0 and the noise in the waveform "pedestal" was determined graphically. The amplitude fluctuations and temporal jitter were calculated using algorithms described in [6] and [7]. The jitter components were calculated using the fundamental and second harmonic for PRFs between 7 and 13 GHz and by using the fundamental for PRFs between 14 and 16 GHz. (The

-- continued on page 35

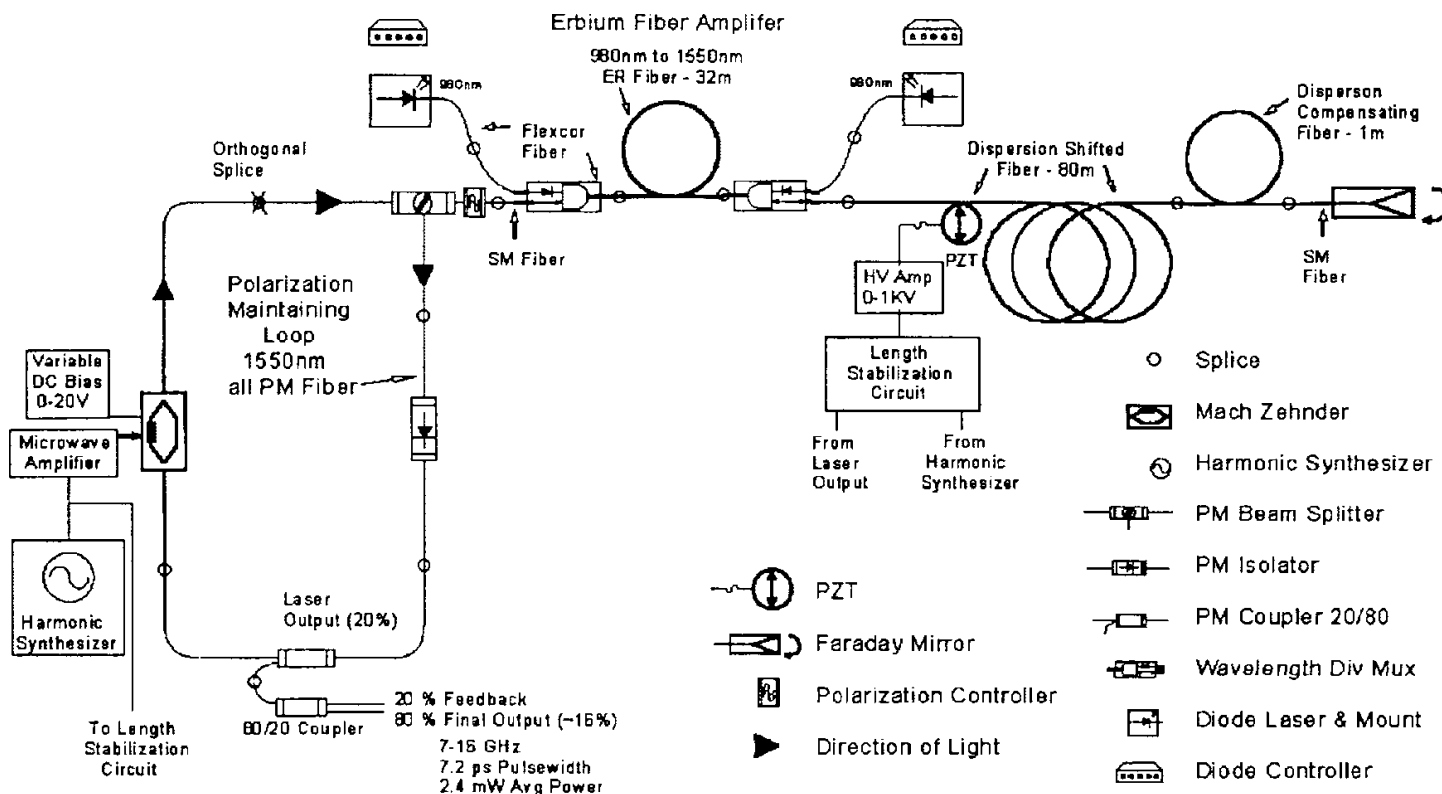


Figure 4. Naval Postgraduate School implementation of a mode-locked sigma fiber laser.

FIBER LASER, continued from page 34

second harmonics were not available for the higher PRFs due to the frequency limits of the spectrum analyzer.)

The laser was mode-locked at 7.0001 GHz and measurements taken at the fundamental and second harmonic. Figure 5 shows a typical microwave spectrum analyzer output with a span of 200 kHz about the fundamental. The region outlined on the trace shows the bounds for both the amplitude jitter, σ_{AJ} , and high frequency temporal jitter, σ_{JHF} . Similar analyzer outputs of the second harmonic of the pulse frequency allow us to separate the temporal jitter from the amplitude jitter [8].

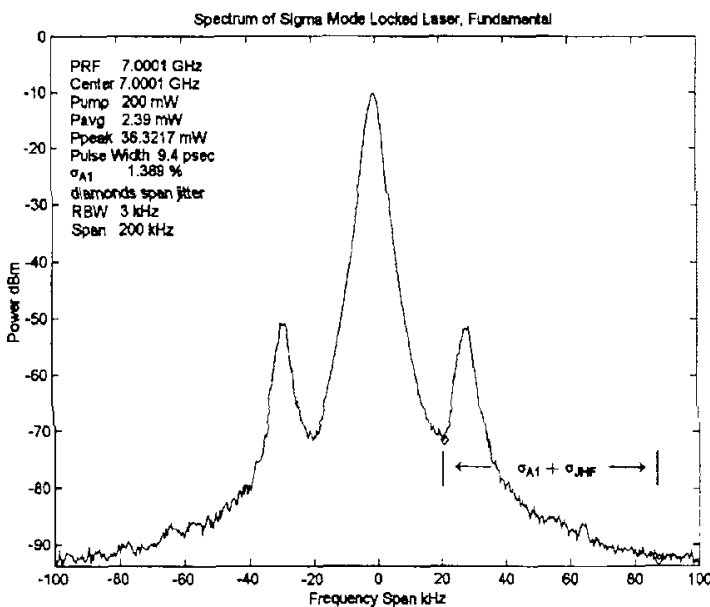


Figure 5. Fundamental mode-locked signal, 7 GHz PRF, 200 kHz span.

The NPS sigma mode-locked laser demonstrated [6] a maximum PRF of 16 GHz, a pulsewidth of 7.2 picoseconds, amplitude noise of 0.23%, temporal jitter of 386 femtoseconds, and the ability to be harmonically mode-locked at twice the modulation frequency of the mode-locker using only 200 mW of diode pump power in the optical amplifier.

Sampling Limitations of the NPS Sigma Laser in an ADC

The measured PRF, pulsewidth, temporal jitter noise, and amplitude jitter directly affect the ability of the laser to be used as a wideband optical sampling system within an amplitude-analyzing analog-to-digital converter (ADC).

The PRF is the sampling rate and the 16 GHz maximum PRF limits the maximum signal frequency to 8 GHz. The other remaining performance characteristics affecting an ADC are discussed in the subsections below.

a. Maximum amplitude jitter: Amplitude jitter in the sampling laser pulse is a problem if its variation is significant enough to exceed an adc step size or least significant bit. A binary-weighted converter with N bits of resolution has $2^N - 1$ quantization levels that can be approximated by 2^N (for most useful values of N). to avoid exceeding one step size, the amplitude variation ΔA must be less than or equal to $\Delta A \leq 2A/2^N$ where $2A$ is the peak-to-peak voltage of the sampled signal. Since amplitude jitter, σ_a , is measured as a function of percentage of peak value, ΔA is rearranged to give a maximum amplitude jitter of $\sigma_{Amax} = 100\Delta A/A \leq 100/2^{N-1}$ (as a percentage). Figure 6 is a plot of σ_{Amax} for $N = 6$ to 12 bits. At 12 bits, the maximum tolerable amplitude jitter is less than 0.05%. The measured amplitude jitter from the NPS sigma laser is 0.23% and is also shown in the figure. From the figure, we note that this limits the use of this laser in an optical ADC with 9 bits of resolution.

b. Maximum temporal jitter: To prevent an amplitude error in an ADC, the maximum temporal jitter is limited to [1] $\Delta\tau_{max} \leq 1/2^N \pi f_m$ where f_m is the maximum frequency of interest. The measured rms temporal jitter in the NPS laser was 386 fs (best measurement). Because of

-- continued on page 36

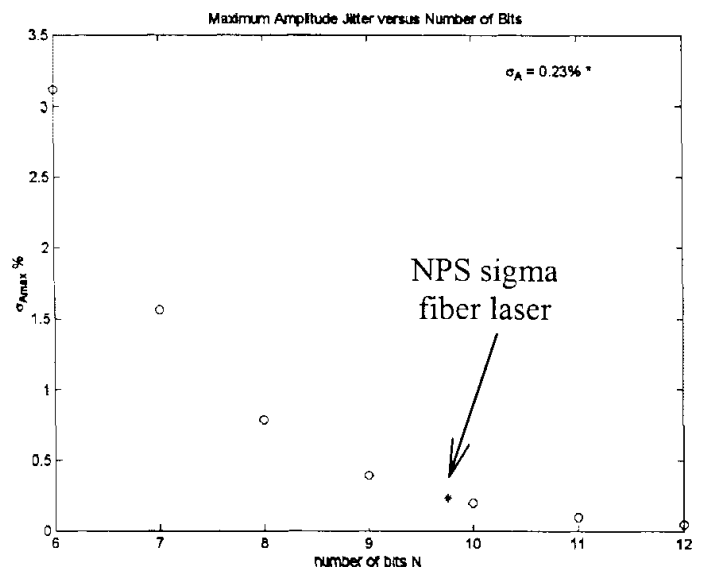


Figure 6. Maximum allowed amplitude jitter vs. number of bits N.

FIBER LASER, *continued from page 35*

the low amplitude jitter, the temporal jitter values at 14.1, 15, and 16 GHz are believed to be lower but the second harmonic spectrum was not available due to the limits of the RF spectrum analyzer. Figure 7 plots the maximum temporal jitter for resolutions of $N = 6$ to 10 bits. Using the measured jitter of 386 fs, the maximum antenna frequencies that can be sampled are listed as Fm_6 through Fm_{10} on the graph. The maximum PRF of our laser was measured at 16 GHz, leading to a maximum signal frequency of 8 GHz (as indicated by the dashed line in the figure). At six bits, the laser temporal jitter is well below the maximum value allowed. For 10 bits, the maximum antenna frequency of interest is limited to 805 MHz for our laser pulse train.

c. Maximum pulsewidth: The maximum electro-optic interaction time (pulsewidth) allowable in an optical sampling system is also a function of the highest frequency of interest, f_m , and the number of bits N [1]. The maximum electro-optic interaction time Δt is given by $\Delta t \leq \sqrt{3}/\pi f_m \sqrt{2^{N-1}}$.

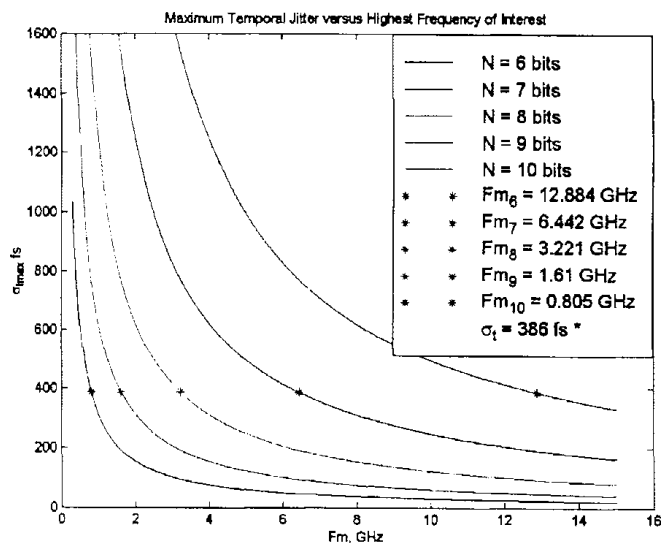


Figure 7. Maximum allowed temporal jitter vs. highest signal frequency.

Figure 8 is a plot of Δt versus the maximum signal frequency, f_m , for resolutions between 6 and 10 bits. The smallest pulsewidth obtained from our laser was 7.2 ps and was used to estimate the maximum RF frequencies that can be sampled. These maximums are listed as Fm_6 through Fm_{10} on the graph. Since the NPS sigma laser is PRF-limited to Nyquist sampling an 8 GHz signal, sampling is limited to 6 or 7 bits. At 10 bits, the pulsewidth limits the maximum frequency of interest to 3.38 GHz.

Summary

The NPS mode-locked sigma fiber laser demonstrated a PRF of 16 GHz, pulsewidth of 7.2 picoseconds, amplitude noise less than 1%, time jitter of 386 femtoseconds, and the ability to be harmonically mode-locked at twice the modulation frequency using only 200 mW of diode pump power

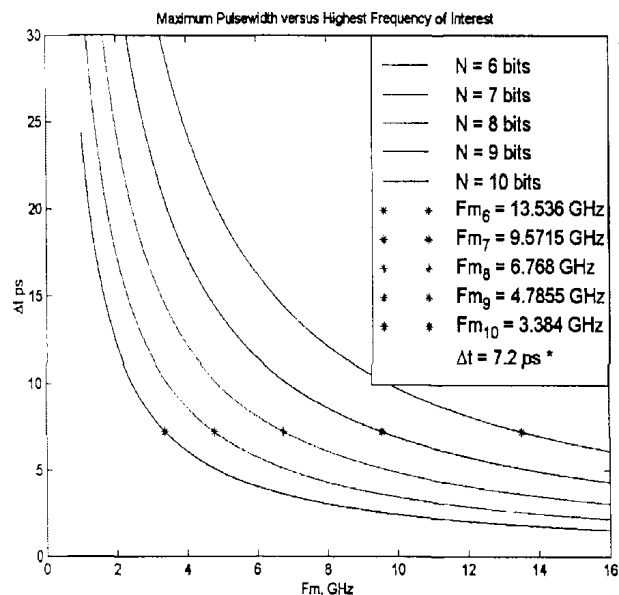


Figure 8. Maximum allowed pulse-width vs. highest signal frequency.

in the optical amplifier. The laser can be used to directly sample a signal bandwidth of 8 GHz at 6 bits, 6.44 GHz at 7 bits, 3.22 GHz at 8 bits, or 1.61 GHz at 9 bits of resolution (limited by the temporal jitter). Work continues to reduce the pulse width and the temporal jitter by optimizing the lengths of the amplifier fiber and the nonlinear fiber, as well as increasing the power of the amplifier pump laser diodes. Integration of the laser sampling subsystem with a microwave sampling circuit (an optical Mach-Zehnder modulator) is also underway.

Acknowledgements

This work was supported by the Naval Postgraduate School's Center for Reconnaissance Research. The authors would like to express their sincere appreciation to Drs. Mike Dennis, Tom Carruthers and Irl Duling III, at the Optical Sciences Division, Naval Research Laboratory, for their encouragement and guidance during the construction of our design.

-- continued on page 37

FIBER LASER, *continued from page 36*

References

1. K. V. Reddy, Ultrafast Optical Clock, Specification Sheet, PriTel, Inc., Naperville, IL, 1998.
2. Henry Taylor, "An optical analog-to-digital converter—Design and analysis," *IEEE J. Quantum Electronics*, vol. QE-15, no. 4, pp. 210–216, 1979.
3. Thomas F. Carruthers and Irl. N. Duling III, "10-GHz, 1.3-ps erbium fiber laser employing soliton pulse shortening," *Optics Letters*, vol. 21, no. 23, pp. 1927–1929, 1996.
4. Thomas F. Carruthers and I. N. Duling III, "A High-Repetition Rate Ultrafast Fiber Laser for Fiber-Optic Communications Systems," Technical Report, Naval Research Laboratory, Washington D.C., 1996.
5. Phillip E. Pace and John P. Powers, "Photonic Sampling of RF and Microwave Signals," Naval Postgraduate School Technical Report NPS-EC-98-009, March 1998.
6. James M. Butler, "Construction and Measurement of an Actively Mode-Locked sigma Laser," Naval Postgraduate School Technical Thesis Report NPS-EC-98-011, June 1998.
7. Ursula Keller, Kathryn D. Li, Mark Rodwell, and David M. Bloom, "Noise characterization of femtosecond fiber Raman soliton lasers," *IEEE Journal of Quantum Electronics*, vol. 25, no. 3, pp. 280–288, 1989.
8. D. von der Linde, "Characterization of the noise in continuously operating mode-locked lasers," *Applied Physics B*, vol. 39, pp. 201–217, 1986.

DECISION MAKING, *continued from page 5*

model called RDM, developed and owned by a contractor firm. The RDM system, developed several decades ago, suffered from many problems. It was used primarily as an automated data processing tool, rather than as a decision support system. Recruit distribution solutions produced by the system were of poor quality, and in fact there was no mechanism in place even to measure the quality of the solutions or to find solutions that were of better quality. Finally, the Marine Corps was heavily dependent on the contractor for this system since it required constant contractor involvement and expenditure.

In Summer of 1998, Dr. Bhargava, working with an ITM student, **LT Kevin Snoop, USN**, delivered RDdss, a decision support system for recruit distribution. The entire process associated with creating a recruit distribution for a particular week consists of a series of steps involving file manipulations, model set up, execution, interpretation of results, and so on. RDdss contains a much improved and contemporary user interface (see Figure 2) in which all operations are performed via a series of switchboards, each of which eventually leads to action screens through which these steps are performed. However, the real benefits of RDdss were in the methods used for making recruit distribution decisions.

First, the problem of assigning recruits to school seats can be modeled mathematically. Feasible solutions take into account

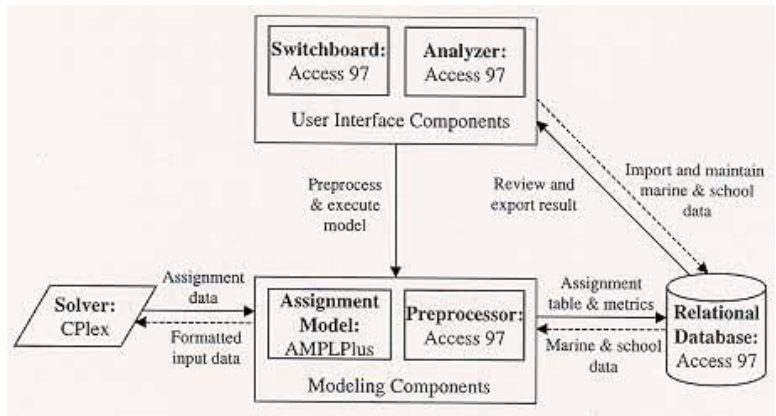


Figure 2. RDdss Architecture

school quotas as well as eligibility requirements such as the Marine's program guarantee and school qualifications (e.g., Age > 18 and Electrical Score \geq 95). While a standard weekly recruit distribution model (about 700 Marines and about 1800 school seats) can admit hundreds of millions of feasible distributions, RDdss uses standard operations research techniques to search through this large space and find distributions of optimal

-- continued on page 38

FEATURED PROJECT

DECISION MAKING, *continued from page 37*

quality.

Second, the system recognizes that good recruit distribution involves making a tradeoff between two conflicting objectives called *fill* (i.e., the number of school seats filled, critical since unfilled seats represent a wastage of committed resources) and *fit* (i.e., the suitability of each Marine to his/her assigned school, and vice versa, important since the choice of school determines the Marine's career path as well as performance). In RDdss, solution quality is defined as a combination of the fit and fill metrics (mathematically, it can be written as $k_1 \text{ Fit} - k_2 \text{ Fill}$, where k_1 and k_2 are weights placed on fit and fill). In any run of the recruit distribution model, the solution produced is optimal only with respect to the specific weights chosen. Therefore, RDdss allows the Marine Corps to game each model instance in order to meet different policy objectives. For example, if in some week it is desired to place more emphasis on filling the maximum number of school seats - with less regard to the quality of fit, then k_2 can be increased. In this manner, RDdss can be used to create multiple solutions, or candidate distributions, for each week.

Third, RDdss provides various mechanisms by which USMC management can understand and analyze the quality of different candidate recruit distributions. For each run, RDdss explicitly reports 4 metrics (Fit, Fill, Average

Waiting Time for Marines, and Number of Unassigned Marines), in both summary and detail forms via graphs, for each candidate solution. It also provides mechanisms to understand why certain recruits were assigned to certain schools, or perhaps not assigned at all. These reports make it easy to compare candidate recruit distributions against themselves and with two extreme solutions (ones in which fill and fit weights, respectively, are set to zero). The model operator can repeatedly adjust the fit and fill weights to produce candidate distributions. In practice, what happens is that one measure can be improved without any losses, or with negligible losses, in the others, and a superior solution is found within 5-10 runs.

RDdss is unique in all the models in the manpower decision making suite in this regard: offering model operators the capability to play what-if games until they arrive at solutions that are consistent with current policy objectives, and offering managers the ability to understand and analyze solutions produced by the system. It also provides high-quality solutions. According to conservative estimates, arrived by assigning dollar values to increase in quality and decrease in unfilled seats, the Marine Corps would save over a million dollars a year by implementing RDdss solutions rather than the ones delivered through its current system. In short, RDdss, if used by the Marine Corps, would help achieve the Marine Corps' manpower vision by helping place the right Marine in the right school at the right time.

UAV RESEARCH, *continued from page 11*

board for passing in-flight telemetry such as kinematics (course, speed, altitude, positions, etc.), video, and other data to CIRPAS mobile and fixed ground and tactical control stations where they are typically saved to tape. These data in the past have then been provided to client researchers for use in their particular projects.

UAVs can be a valuable asset to the warrior and NPS will soon demonstrate that the UAV and target track kinematics data, photos and other digital telemetry data can be provided via the STL to the warriors on a near real time basis using existing or COTS equipment and at a low cost. This will be accomplished by using the STL to receive digital UAV telemetry data and to provide this info to the warriors via GCCS (Global Command and Control System) over the SIPRNET. The STL already

has a full CINC level GCCS suite with SIPRNET connectivity to all the other GCCS sites.

The simplest way to accomplish this task is to have a CIRPAS UAV ground station instruct the UAV to establish a UAV modem-to-STL modem connection by placing a cell (satellite) phone call to the normal STL telephone number. The UAV currently has a 4800-baud capability going to 9600 baud later this year. The UAV will then be instructed to pass digital UAV and target track kinematics data to the STL. STL researchers then convert the digital data into rainform GOLD formatted messages which allows automatic insertion of the digital UAV data into the GCCS database for display as tracks on the warriors' GCCS or JMCIS displays. Periodically the UAV will use a screen grabber to send digital visual and IR spectrum snapshots (one video frame per snap-

-- *continued on page 39*

UAV RESEARCH

UAV RESEARCH, continued from page 38

shot) over the modem link to the STL. The STL researchers then post the snapshots on a STL web page for viewing by warriors over the SIPRNET.

A better way is to have the CIRPAS UAV ground sites send the same digital telemetry information using high speed modems or over the INTERNET to the STL. In this way more data including more snapshots can be sent to the STL for more near real time access by the warriors over the SIPRNET. The capability already exists for the UAV to send the digital data to the CIRPAS ground sites via high bandwidth Ku band satellite links. This capability will allow fleet users to watch the UAV track and it's contacts on the JMCIS/GCCS Common Operational Picture (COP) which has two major C4I ramifications for fleet use. First, the fleet does not have to use its own assets to detect and track the UAV and its targets since they will be injected by the STL over the SIPRNET into the GCCS database and thus already be visible on the fleet's COP. Second, this will also allow the fleet to use the UAV in over-the-horizon

(OTH) operations while maintaining C2 of the UAV using the COP.

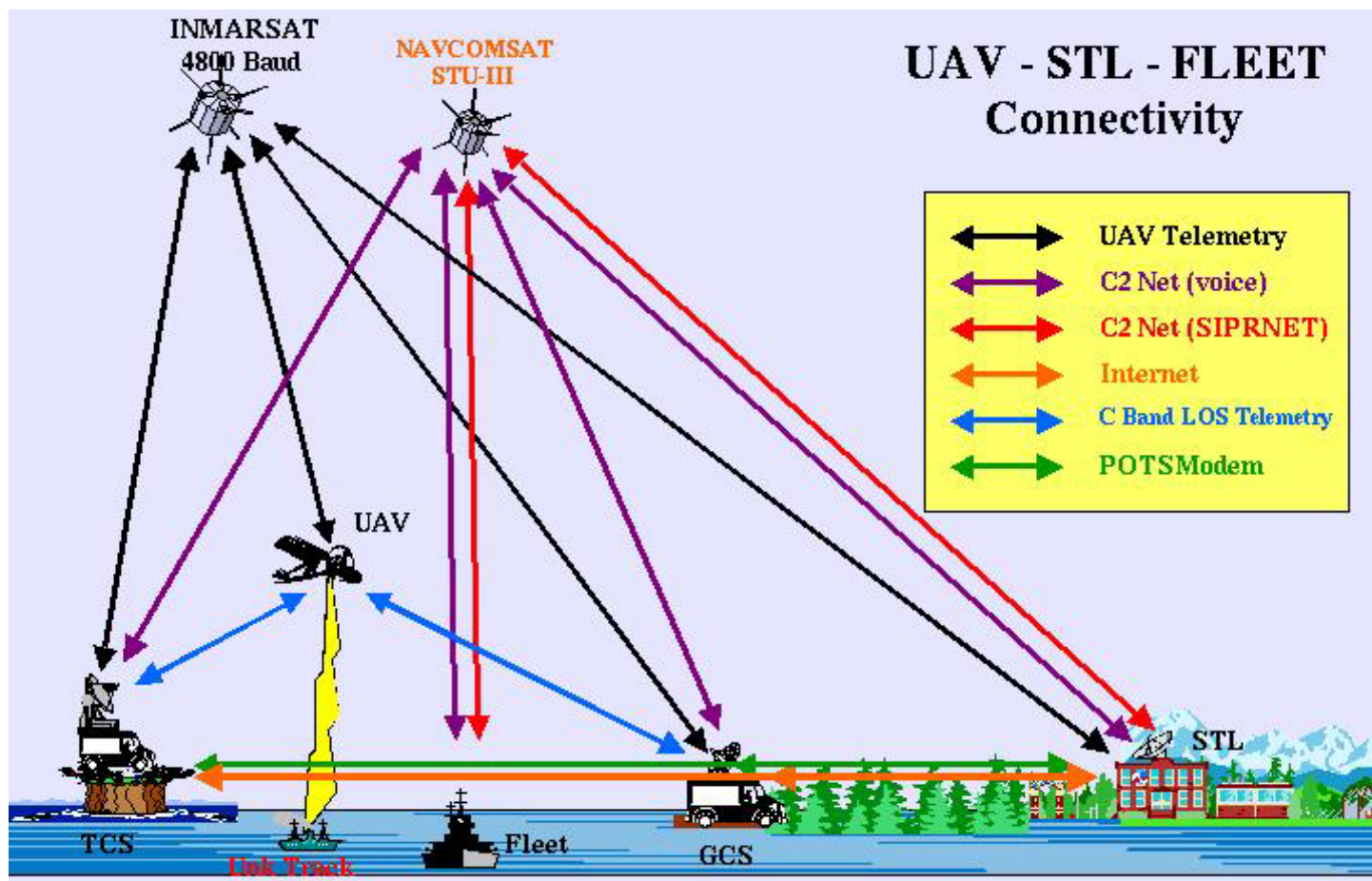
After successful completion of these low cost demos, a next stage is perceived to involve sending the UAV video via existing Ku Band satellite to a GBS uplink site for broadcast over GBS to the warriors. The STL is also a GBS downlink site.

Thesis students are being recruited to help or lead in establishing these modem and Internet links on a reliable basis, develop and automate the UAV digital data to rainform GOLD format, automatically insert it into the STL GCCS database for transmission to GCCS sites on the SIPRNET, and develop the STL UAV web page where the digital snapshots and other digital telemetry can be posted for viewing by SIPRNET users, and to then automate this process. Proof of concept is targeted during a Fleet Battle Experiment (FBE) to be held in Monterey Bay this year.

Rapid Prototyping of Avionics System for UAVs

The purpose of a Rapid Prototyping System (RPS) is to aid

-- continued on page 40



UAV RESEARCH, *continued from page 39*

the avionics systems engineering process by providing a set of integrated tools that allow the engineer to quickly design, simulate, implement and flight test avionics software. The RPS was developed by Associate Professor **Isaac Kaminer** and students enrolled in the Avionics Curriculum at the NPS. It utilizes the Realsim Product Family of software tools developed by Integrated Systems, Inc. (ISI) of Sunnyvale, California. This software collection along with the ground station and FROG unmanned aerial vehicle (UAV) allows avionics projects to be developed from initial concept to final flight testing. The iterative system design process is greatly accelerated since changes to the avionics software can be made quickly using the autocode feature of Realsim and, therefore, does not require extensive manual reworking of the real-time controller computer code. For example, during a recent flight test, code changes were made, compiled, linked and executed while the aircraft was airborne. This is very important in the NPS academic setting as it allows the officer/students to complete projects from the initial design, to the final testing phase in the limited amount of time available.

The FOG-R flight vehicle was obtained from the U. S. Army's TEXCOM Experimentation Center at Fort Hunter Liggett, California. Originally wire guided, the aircraft has been converted to utilize standard Futaba radio control equipment common to R/C enthusiasts. Nicknamed the FROG, the aircraft is a high wing monoplane with the engine mounted on a pylon atop the twelve-foot span. It features two payload bays that can hold a total of twenty pounds of equipment. The aircraft is equipped with an avionics and sensor suite that includes an IMU, DGPS, air data sensors and video camera. This suite has been used to

develop and flight test a variety of autonomous functions. Due to the high replacement cost of the computing equipment and the tenuous nature of UAV operations, the ground station concept is employed to reduce overall risk of the program. The ground station hosts the Realist software and provides all the computational power used to perform the flight management and data collection functions of the RPS.

The Voice Control System (VCS) for the FROG UAV, ViA Wearable, was developed together with ViA, Inc. of Northfield, Minnesota. It utilizes a wearable computer manufactured by ViA that allows a user to give voice commands to the aircraft while monitoring aircraft's motion via a compact flat panel display. The display includes a movable map with the aircraft's GPS position and the video broadcast by the onboard camera. The voice control menu includes commands to store current video images. In addition to the standard RPS, the VCS requires the use of a laptop computer to translate commands between the ViA Wearable and the RPS. The VCS software programs that run on the laptop and wearable computers are the only custom made components of the system.

Wireless Power Transmission in Miniature (Micro) Air Vehicles

DARPA and several other DoD agencies currently have research programs with the objective of developing a miniature (micro) air vehicle (MAV) that would have both military and civilian applications. The first generation would be only a couple of inches in size, which would allow it to be man-portable and able to fly inside of buildings. A vehicle this small could be used to monitor dangerous environmental hazards (like the inside of a contami-

--continued on page 41

Experimental and Numerical Studies of Flapping-Wing Propulsion

Distinguished Professor **Max Platzer** and Research Assistant Professor **Kevin Jones** of the Department of Aeronautics and Astronautics are investigating experimentally and numerically the use of flapping wings for the propulsion of micro-air vehicles. Experiments are carried out in the NPS 5' x 5' low-speed wind tunnel using a device which allows for two moving airfoils, each with two degrees of freedom and adjustable phasing between the pitch and plunge motions of the airfoils. Also, the pitch and plunge amplitudes and frequencies of oscillation can be adjusted. These experiments allow the systematic measurement of the major parameters which affect the thrust generated by wing flapping. In addition, numerical simulations are performed using linearized theory, an unsteady panel code, and a Navier-Stokes code. The comparison between the thrust measurements and the numerical predictions is generally quite good and therefore provides confidence in the use of this experimental/numerical information for the design of micro-air vehicles using flapping wing propulsion. The design and construction of such a micro-air vehicle has been completed and wind tunnel tests are currently in progress.

UAV RESEARCH, *continued from page 40*

nated nuclear facility) and even gather information in hostage situations. Subsequent generations of the vehicle could be made as small as the current technology permits.

The design of such a small vehicle presents some unique engineering challenges. Obviously as the size of the vehicle is reduced, the weight and power consumption of the systems on board must also be reduced. One possible means of reducing weight is to "beam" microwave energy to the vehicle, which is then converted to a dc signal that drives a motor. This approach is called wireless power transmission (WPT), and it was first demonstrated in 1964. Since WPT eliminates the need for a battery on board, the potential volume and weight savings are significant. Microwave power beaming has a fundamental thrust-to-weight advantage over conventional power sources when the vehicle size is very small (a couple of inches or less).

Research by Associate Professor **David Jenn** and student **Robert Vitale** has demonstrated the WPT concept using a prototype developed at NPS. The prototype is the same size as a conventionally powered UAV under development by Lutronix, Inc. It is approximately 2 inches in diameter, 4.5 inches long and has a rotor diameter of 5 inches. The entire body of the UAV serves as the antenna for reception of the microwave power. The received microwave signal is rectified and then used to power the motor which drives the rotor. Research has also shown that current radar waveforms such as those used by the AN/SPS-65 surface search radar in the NPS Radar Laboratory are capable of powering the UAV.

Other related issues are also being investigated, such as the effects of wall losses and multiple reflections, the mitigation of radiation hazards, and the efficiencies of various ground station configurations.

Other UAV Studies

- Associate Professor **Rick Howard**, Department of Aeronautics and Astronautics, has undertaken a wind-tunnel study to design and test a telescope fairing for the Altus UAV based at CIRPAS. Sandia National Laboratories is funding this study, which is concerned with designing a blister fairing to minimize the resulting steady and high-frequency air loads on the telescope, which requires a fairing with an opening to maintain

optical quality. Issues also involve the cavity resonance problem, payload temperature control, and the effect of the fairing on the drag and flying qualities of the UAV.

- Dr. Howard is assisting the Center for Naval Analyses (CNA) in a NAVAIR-sponsored study to identify and assess technologies toward a viable maritime UAV. The study includes Vertical Takeoff and Landing (VTOL) and Medium Altitude Endurance (MAE) options.
- A 1/3-scaled radio-controlled instrumented sailplane is being developed to simulate the flight mechanics of the drop of the NASA Apex 15-meter wingspan sailplane being developed at NASA Dryden Flight Research Center. The Apex is a high-altitude unmanned aircraft to be carried aloft to 100,000 feet by a weather balloon, then dropped and flown through a flight experiment by a remote pilot before landing at Edwards AFB. The data will provide information for designing future high-altitude aircraft for atmospheric measurements.
- Development of the avionics system definition for a system of networked UCAVs used in a close air support mission is being pursued by Assistant Professor **Russ Duren** of the Department of Aeronautics and Astronautics. He also is performing feasibility studies and initial system design to incorporate a High Power Microwave weapon into a UCAV, and a system-level trade study concerning the use of UCAVs as electronic warfare platforms.
- An autonomous rotorcraft project being pursued by Dr. Duren is to develop the avionics hardware and software for a small autonomous helicopter to be used for research in UAVs. He is also developing a dynamic simulation model for the helicopter.
- Associate Professor **Isaac Kaminer** is investigating the necessary sensor and algorithmic requirements for the successful autoland of an autonomous aircraft aboard a naval ship using passive sensors only. In particular, the research focuses on the subject of fusing asynchronous, multi-rate, multi-resolution data available from a sensor suite that may include INS, GPS, FLIR, vision, laser and ultrasonic sensors. The research issues being addressed are: 1) extraction of navigation data from vision and laser systems; 2) development of fusion algorithms that explicitly address the multi-spectral, multi-resolution, and multi-rate characteristics of sensor data; and 3) how to properly use the information provided by the fusion algorithms to successfully control the vehicle to the landing site and land it there in the presence of severe environmental conditions and possible sensor failures (robust sensor-based control).

METEOROLOGY LABS, *continued from page 13*

description of the shipboard and buoy systems used and past experiment involvement can be viewed on the site <http://www.met.nps.navy.mil/~jonesk>.

Another focus of activity in the Marine Atmospheric Boundary Layer Laboratory is the study of atmospheric processes near the surface in marine polar regions. Research Associate Professor **Peter Guest** examines the exchanges of heat, moisture and momentum between the atmosphere and ice-covered or liquid oceans. This involves multi-national and multi-disciplinary efforts using conventional research vessels, icebreaking vessels, and camps set up on ice floes. Current projects include the ONR-sponsored Labrador Sea Deep Convection Experiment (LSDCE) and the NSF-sponsored Surface Heat Budget of the Arctic (SHEBA) experiment. During the winter of 1997, as part of the LSDCE, Guest and colleagues sampled some of the most extreme ocean cooling ever directly measured. This cooling had a profound effect on the ocean, causing the surface waters to sink and mix to depths of over 1500 meters, which is more than an order of magnitude greater than typical ocean mixing depths (see the web site <http://met.nps.navy.mil/~guestps/labsea> for details). The SHEBA field program was centered on an icebreaker that was frozen into the Arctic Ocean for an entire year, September 1997 to September 1998. This is only the second time a ship has ever accomplished this feat, the first occurring at the turn of the century. A surface layer program led by Dr. Guest and three other principal investigators involved the continuous measurement of over 100 distinct atmospheric variables for the entire year using four remote meteorological stations, a large tower and other instruments placed on ice floes. With an elevation of 20 meters, the tower was the tallest such structure ever constructed on sea ice. The tower served as a platform for measurements of temperature, humidity, surface wind vector, vertical heat flux and vertical momentum flux at five different levels (Figure 2).

Additional research in the Marine Boundary Layer Laboratory, led by Assistant Professor **Qing Wang**, emphasizes two aspects of the boundary layer study. One is to understand the physical processes related to various marine boundary layer phenomena, such as the evolution of the marine stratocumulus clouds and their interaction with boundary layer aerosols. The other is to study various parameterizations of the marine boundary layer processes in order that they can be represented appropriately in models of different time and spatial scales. These two research foci are well represented by several projects in the lab sponsored by various funding agencies such as the National Science Foundation (NSF), NASA, and the Naval Research Laboratory

--continued on page 43



Figure 2. A tower used in the SHEBA field program served as a platform for measurements of temperature, humidity, surface wind vector, vertical heat flux, and vertical momentum flux at five different levels.

METEOROLOGY LABS, *continued from page 42*

(NRL). These include two phases of the Aerosol Characterization Experiment (ACE), and the First ISCCP (International Satellite Cloud Climatology Project) Regional Experiment (FIRE-III). ACE-1 and ACE-2 intensive measurements emphasized boundary layer aerosols and their interaction with boundary layer clouds in clean and polluted marine environments. FIRE-III was made over the Arctic Ocean to study the characteristics of the Arctic low-level clouds and their interaction with the ice/water surfaces. Aircraft measurements, which were essential components of all experiments, provided the primary data set for analyses in the lab. These datasets are also the basis upon which boundary layer parameterizations are examined.

Numerical Modeling Research Laboratory

One of the highlights of the Numerical Modeling Laboratory this year was the successful numerical simulation of the annual cycle in the California Current region as part of an ONR sponsored research effort led by Professor **Robert Haney**. The simulation was carried out by **Bob Hale** (Meteorologist) and **LT Joe Donato, USN**, (METOC Thesis student) using NPS' Cray (Vis-Lab) and SGI Origin

2000 (IDEA-Lab) computers. Recent observations of the California Current by scientists at Oregon State University and the University of Washington using data from quasi-Lagrangian surface floats and satellite altimetry has revealed a distinct seasonal cycle in the California Current and its associated energetic eddies. In particular, the eddy kinetic energy (EKE) at the surface has been found to form (by current instability processes) near the coast in the spring, and to move offshore during the fall and winter while greatly decreasing its intensity beyond about 300-500km from shore. Previous interpretations of this seaward decrease of surface EKE west of its primary source near the coast have been expressed in terms of an unspecified dissipation process. The recent NPS simulations, on the other hand, have shown that the EKE at the surface decreases westward from the coast because of the vertical redistribution of the EKE to the deep ocean. According to the model simulations, the EKE does not dissipate as it moves offshore, rather it simply spreads downward to the deep ocean, resulting in a decrease at the surface. A nonlinear process involving a transfer of energy from high to low vertical wave numbers, the details of which are still being investigated, accomplishes this apparent spreading.

In a separate study, Professor Haney and collaborators from Universitat de les Illes Balears, Palma de Mallorca, Spain, have documented and interpreted a new mode of Upper Ocean variability in the Alboran Sea. The results of the study are presently being utilized operationally by all three detachments at the U. S. Naval European Meteorology and Oceanography Center, Rota, Spain.

Remote Sensing Research Laboratory

The Remote Sensing Laboratory (RSL), under the direction of Professor **Philip Durkee** and Lab Manager **Keith Nielsen**, operates state-of-the-art computer hardware and software for collecting, archiving and processing weather satellite imagery that is unique within a university setting. The RSL collects NOAA POES (Polar Operational Environmental Satellites) multi-

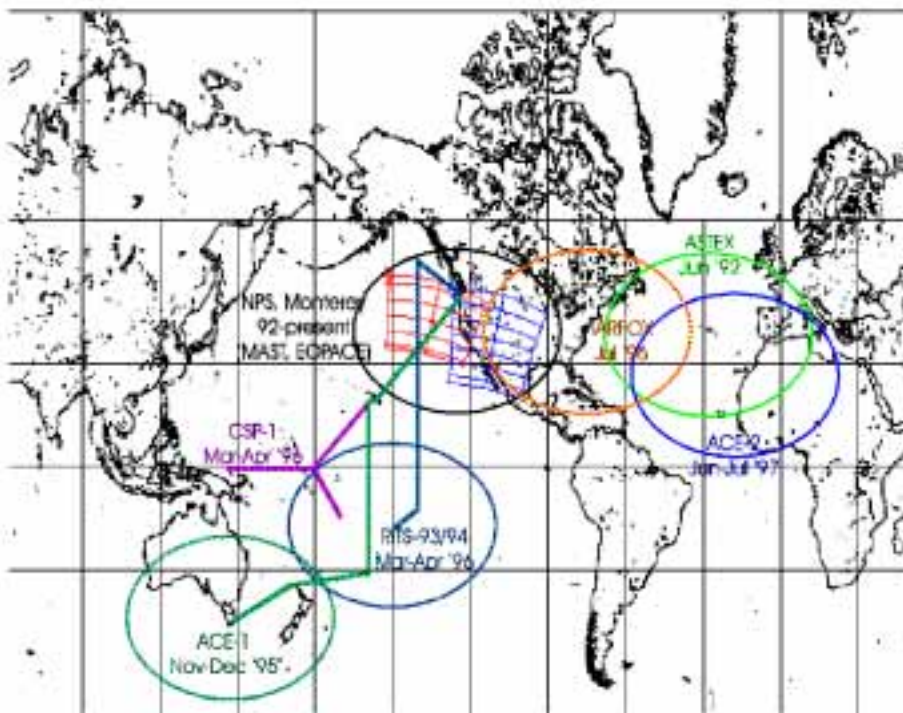


Figure 3. Sites of experiments participated in by NPS' Remote Sensing Laboratory

--continued on page 44

METEOROLOGY LABS, *continued from page 43*

spectral imagery on site with a SeaSpace Corporation TeraScan system hosted on a suite of Sun workstations. The lab's POES archive includes data covering western North America and eastern North Pacific Ocean, and extends back to 1992. Additionally, the lab collects real-time DMSP (Defense Meteorological Satellite Program) data via a classified ground station and has access to GOES (Geostationary Operational Environmental Satellites) imagery from the Naval Research Laboratory - Monterey. The RSL also has the ability to process archived SeaWiFS (Sea-viewing Wide Field-of-view Sensor) imagery and in the near future will have the ability to collect local SeaWiFS data sets as well.

In addition to the fixed groundstation, the RSL operates a portable shipboard system with a gyro-stabilized tracking antenna for AVHRR collection both at sea as well on remote field experiment sites. In the summer of 1994 the RSL hosted MAST (Monterey Area Ship Track), an international experiment to investigate the effects of ships on cloud properties. Since 1992, lab personnel have participated directly in the following experiments:

- ACE-2 (Aerosol Characterization Experiment) 6/97-7/97 Canary Islands, Spain
- TARFOX (Tropospheric Aerosol Radiative Forcing Experiment) 6/96-7/96 Wallops Island, Virginia
- CSP (Combined Sensor Program) 3/96-5/96 American Samoa
- ACE-1 (Aerosol Characterization Experiment) 1/95-12/95 Tasmania, Australia
- MAST (Monterey Area Ship Track) 6/94-7/94 Monterey, California
- RITS-II (Radiatively Important Trace Species) 10/93-12/93 French Polynesia
- RITS-I (Radiatively Important Trace Species) 4/93-5/93 French Polynesia
- ASTEX (Atlantic Stratocumulus Transition Experiment) 6/92-7/92 Azores, Portugal

Research applications include retrieval of aerosol properties, cloud microphysical properties, Ocean turbidity, and marine atmospheric boundary layer properties.

Synoptic/Mesoscale Laboratory

The Synoptic/Mesoscale Analysis and Forecasting Laboratory is focused on the collection and use of a variety of local meteorological observations. Meteorol-

ogy Department faculty and staff in the Synoptic and Mesoscale Lab are Associate Professor **Wendell Nuss**, Research Assistant Professor **Douglas Miller**, and Mr. **Richard J. Lind**. Over the years, NPS has established itself as a leader in radar wind profiling by operating both a 404 MHz and 915 MHz profiler at Ft. Ord. These data are collected along with other profiler observations in California and displayed on a web page (<http://www.met.nps.navy.mil/~lind/profiler/coastprof.html>) for wide use by the meteorological community, especially the National Weather Service (NWS). Through the NPS participation in the five-year (1992-1998) Office of Naval Research sponsored Real-time Environmental Information Network and Analysis System (REINAS) project in collaboration with the University of California, Santa Cruz, the profiler observations and a number of other local meteorological data are now collected in real-time to provide a Monterey Bay mesoscale observing network (mesonet). This mesonet has been growing through informal cooperation with a large number of local meteorological agencies in an unfunded group referred to as the Bay Area Mesonet Initiative (BAMI). NPS presently leads the BAMI group and rapid progress is being made toward a more extensive mesonet that extends beyond the Monterey Bay region. Observations collected from this mesonet are being used at NPS for research in mesoscale data assimilation by Professor Nuss, local atmospheric modeling and model validation by Research Professor Miller, and the impact of topography on thermally-driven circulations (sea breeze) by Professor Nuss and students. In addition, other members of BAMI make use of these data for their own research or operational forecasting needs.

A significant application of the collection of local observations in recent years has been to make real-time forecasts with a mesoscale numerical model using these local observations. Research Assistant Professor Miller runs a numerical model twice per day to generate forecasts down to a grid resolution of 12 km. These quasi-operational forecasts are delivered to three NWS offices and are available on the web (<http://www.met.nps.navy.mil/~dmiller/MM5>) for use by any interested meteorologist. In addition, these model forecasts are used for instruction and research in weather forecasting at NPS by various Department faculty and students. The challenge of operational modeling in the Synoptic Mesoscale Laboratory has greatly accelerated NPS research on data assimilation using multiquadric interpolation techniques, which have been pioneered by Professor Nuss.

NAVY-NASA, continued from page 16

turbulent fluxes in response to surface and cloud characteristics.

NASA Global Aerosol Climatology Project (GACP)

Professor **Philip Durkee**, Department of Meteorology, is a member of the NASA GACP Aerosol Radiative Forcing Science Team by virtue of selection and funding of two proposals in a recent NASA competition. GACP was established in 1998 as part of the Global Energy and Water Cycle Experiment (GEWEX). Its main objective is to analyze satellite radiance measurements and field observations to infer the global distribution of aerosols, their properties, and their seasonal and interannual variations. The resulting data sets and analysis products will be used to improve understanding and modeling of the climate forcing due to changing aerosols, including both the direct radiative forcing by the aerosols and the indirect radiative forcing caused by effects of changing aerosols on cloud properties. In Phase I of GACP, a 20-year global climatology will be compiled of aerosol forcing data from satellite observations and field observations for use in climate models. The aerosol data set and eventually the aerosol radiative forcing data set will be based on multiple satellite data streams, the combination of satellite and aerosol tracer model results where appropriate, surface-based aerosol measurement networks and other data available from the research community. The U.S. Navy benefits from this activity through extension of these techniques to operational analysis of aerosol properties needed to assess impacts on battlefield observations, communications, and performance of sophisticated weapon systems.

Efficient Network Policy Management Using a SAAM Server

In this project, Assistant Professor **Geoffrey Xie** and Associate Professor **Bert Lundy**, Department of Computer Science are researching and prototyping efficient network policy management services as required by NASA information networks. The service will be built within a server and agent based active network management system being developed for the next generation Internet at NPS with DARPA support. The management system, called SAAM, has the capability of deploying a logical server to monitor and control all physical routers in a selected network administrative region. It is anticipated that SAAM

will significantly improve network policy management in three ways. First, the SAAM server presents an ideal place to maintain the central database of policies for an administrative region. Second, SAAM's path centric approach for resource management might be key to efficient network policy representation and checking, especially for new generation of networks where Quality of Service (QoS) are important policy parameters. Third, SAAM enables centralized enforcement of policies. Specifically, SAAM dictates that all functions of a router, including policy enforcement, will be downloaded from the server and these functions can only be updated by server dispatched agents. It is very important to both the Navy and NASA that their information networks continue to be secure, efficient, and user friendly after transition to high data rate and integrated services. Efficient policy management is one of the key requirements.

Understanding Seasonal to Decadal Climate Changes through the Combined Use of Improved Models and Satellite Data

Professor **Bert Semtner** along with Research Assistant Professors **Robin Tokmakian** and **Julie McClean** of the Department of Oceanography are examining the low frequency variability of the global ocean through the joint use of altimetric data and a high resolution global ocean circulation model. Altimeters measure the change in sea level and by combining these data with a realistic ocean model, we can relate the surface changes of sea level to changes in temperature or salinity below the surface which may be indicators related to climate change. Data gathered by several satellites are used, of which the most accurate is the NASA and CNES (the French Space Agency) Topex/Poseidon altimeter. As members of the Topex/Poseidon Science Working Team and the Jason (next generation altimeter) Science Working Team, model fields are provided to others on the team to test, validate, and understand their calculations in regard to the sampling patterns of the satellites, estimates of the ocean's mean circulation pattern, and various physical processes occurring in the ocean. Also included in the research is the use of other satellite data including the Navy's GEOSAT satellite which was operational in the 1980s and the currently flying Navy GFO satellite. Although the research concentrates on the lower frequencies of variability in the ocean, the methods developed through the joint use of altimeters and ocean models are also applicable on shorter

--continued on page 47

CONFERENCE CALENDAR

Conferences/Meetings at the Naval Postgraduate School

Date	Title	Sponsor
8-11 Feb 99	4th National Turbine Engine HCF Conference (UNCLAS)	Naval Air Systems Command, co-sponsored by U.S. Air Force and Universal Tech Corp of Dayton
8-26 Feb 99	Recent Results in Warfighting Technologies Workshop '99	NPS
9-10 Feb 99	ONR Virtual Environment Training Technology (VETT) Program (UNCLAS)	Office of Naval Research/NPS
11-12 Feb 99	ONR Workshop on Spatial Knowledge Acquisition in Large-Scale Virtual Environments (UNCLAS)	Office of Naval Research/NPS
22-26 Feb 99	1999 IRIS Specialty Group Meetings on Passive Sensors and Active Systems (SECRET)	Defense Logistics Agency
1-5 Mar 99	1999 Sensors, Electronics and Battlespace Environments (SEBE) Technology Area Review and Assessment (TARA) (SECRET)	Director of Defense Research and Engineering and Office of Naval Research
8-12 Mar 99	Hardened Electronics and Radiation Technology (HEART) Conference for 1999 (SECRET)	Defense Special Weapons Agency, Sandia National Laboratories, Air Force Research Laboratory, U.S. Army Space and Missile Defense Command, Strategic Systems Program Office
8-12 Mar 99	Annual Classified Advanced Technology Update	NPS
15-19 Mar 99	15th Annual Review of Progress in Applied Computational Electromagnetics (UNCLAS)	NPS/Applied Computational Electromagnetics Society
30 Mar-1 Apr 99	10th Annual U. S. Army Tank Automotive and Armaments Command Ground Vehicle Survivability Symposium (SECRET)	American Defense Preparedness Association and U.S. Army Tank-Automotive and Armaments Command
26-30 Apr 99	Technology Review and Update	NPS
4-6 May 99	National Defense Industrial Association 49th Annual Bomb and Warhead Technical Meeting (SECRET)	National Defense Industrial Association
4-7 May 99	Principles of Electro-Optical, Infrared and Laser Counter-measures (UNCLAS)(1st 3 days) (SECRET)(4th day)	Association of Old Crows
22-24 Jun 99	45th Tri-Service Radar Symposium (SECRET/NOFORN)	Naval Research Laboratory
18-21 Jan 00	AIAA Strategic and Tactical Missile Systems Conference (SECRET/NOFORN)	American Institute of Aeronautics and Astronautics
20-24 Mar 00	16th Annual Review of Progress in Applied Computational Electromagnetics (UNCLAS)	NPS/Applied Computational Electromagnetics Society
1-4 May 00	Forty-Fifth Annual Joint Electronic Warfare Conference (SECRET)	Naval Air Warfare Center

For additional information, please contact the NPS Conference Coordinator, Elaine Christian, at (831) 656-2426 or e-mail echristian@nps.navy.mil

FY98 RESEARCH PROGRAM

NAVY/NASA RESEARCH, *continued from page 45*

time scales. This benefits both NASA and the Navy by knowing the changes not only at the surface but also at depth.

NASA/JPL Space Research

NASA's Jet Propulsion Laboratory (JPL) sponsors research projects at NPS in several areas. Associate Professor **I. Michael Ross**, Department of Aeronautics and Astronautics, and his graduate students have designed Jupiter-gravity-assist trajectories to Pluto and performed mission analysis for the Mars 2007 opportunity. In the coming years, JPL intends to employ aerocapture technology as part of its missions to Mars and various other planets. In particular, the micro-missions to Mars employ small spacecraft that could be launched as a secondary payload. Aerocapture and aerobraking technologies are on the list of possibilities that offer a means for maximizing the payload at Mars. Professor Ross and his students have developed a software package called ACAPS that can rapidly simulate the aerocapture phase of the mission. This code is now used at JPL for their project design studies. In an ongoing research project, the code is being expanded to include aerobraking. This module will be used to perform trade studies to determine if a combination of aerocapture and aerobraking will help alleviate the tight mass constraints on the upcoming micro-missions to Mars.

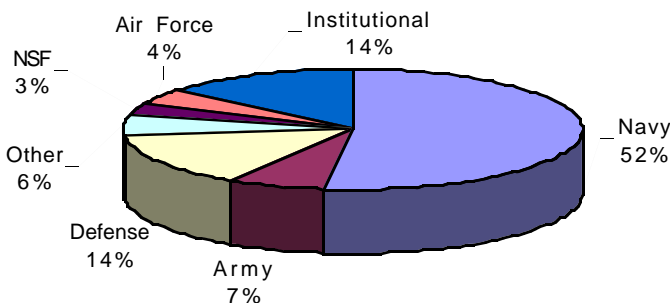
LITTORAL USW SENSOR, *continued from page 23*

govern HSI performance. Knowledge of these sensitivities will lead to an understanding of how to best exploit a submarine's hyperspectral signature and how best to mitigate the limitations of this class of sensor.

Building on the understanding of HSI's limitations and sensitivities, employment schemes will be iteratively simulated to determine maximum performance employment profiles. These profiles will then be generalized into rules for sensor use.

Finally, as a means for determining the operational implications of an HSI system employed in this manner, the model will be supplied with region specific environmental information and likely threat submarine characteristics. These data, coupled with optimal employment profile information, will be used to simulate realistic scenarios that an HSI sensor would likely face in future utilization. In doing this, it will be possible to estimate probabilities of detection in these various scenarios and thusly provide insight into the operational value of such a system.

FY98 Research and Other Sponsored Programs**



Size of program: \$35.3 million

- 146.3 faculty workyears
- 86% externally funded
- 176 student workyears
- 14% internally funded

** includes Distance Learning, Short Courses, Course and Curriculum Development, Student Experience Tours.

MSHN, *continued from page 20*

application, the SA gathers information from the RSS and the RRD, then invokes one of a family of scheduling heuristics that assigns resources to applications. The SA is always prepared to reschedule after resource casualties and changes in command direction.

Interaction between applications and the MSHN system is accomplished via the MSHN Client Library. The Client Library is "wrapped" around adaptive and non-adaptive applications, intercepting specific system calls that make use of resources. The Client Library monitors resource status, and reports it to the MSHN Resource Status Server, using this "wrapping" technique pioneered by **CPT Matt Schnaidt, USA**, while at NPS. Resources used by particular applications are reported to the MSHN Resource Requirements Database, ensuring that it contains accurate and up-to-date information on application resource requirements. When a system call requests execution of another application, it is caught by the Client Library and passed on to the MSHN Scheduling Advisor.

RESEARCH DIRECTORIES

RESEARCH OFFICE

Associate Provost and Dean of Research

David W. Netzer Code: 09
Phone: 831-656-3241
Mail: dnetzer@nps.navy.mil

Director of Research Administration

Danielle Kuska Code: 91
Phone: 831-656-2099
Mail: dkuska@nps.navy.mil
research@nps.navy.mil

Administrative Officer

Judy Joyce Code: 91JJ
Phone: 831-656-2098
Mail: jjoyce@nps.navy.mil

Administrative Support Assistant

Dolores Jackson Code: 91DJ
Phone: 831-656-2098
Mail: djackson@nps.navy.mil

Conference Coordinator

Elaine Christian Code: 92
Phone: 831-656-2426
Mail: echristian@nps.navy.mil

Research Publications

Alice Roberson Code: 91AR
Phone: 831-656-2272
Mail: aroberson@nps.navy.mil

Research Support Services

Teri Jay Code: 91TJ
Phone: 831-656-1044
Mail: tjay@nps.navy.mil

Research Financial Analyst (Reimbursable Programs)

Laura Ann Small Code: 91LS
Phone: 831-656-2271
Mail: lsmall@nps.navy.mil

Research Administration Assistant (Direct Funded Research, Page Charges, Technical Reports)

Nenita Maniego Code: 91NM
Phone: 831-656-2273
Mail: nmaniego@nps.navy.mil

Thesis Processor

Sandra Day Code: 91SD
Phone: 831-656-2762
Mail: sday@nps.navy.mil

Assistant Thesis Processor

Marietta Henry Code: 91MH
Phone: 831-656-3050
Mail: mhenry@nps.navy.mil

RESEARCH CENTERS

Center for Autonomous Underwater Vehicle (AUV) Research

Professor Anthony Healey, Director

Center for Civil Military Relations

Associate Professor Paul Stockton, Director

Center for Diversity Analysis

Professor George Thomas, Director

Center for INFOSEC (Information Systems Security) Studies and Research

Assistant Professor Cynthia Irvine

Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS)

Robert Bluth, Director

Center for Joint Services Electronic Warfare Simulation and Modeling

Associate Professor Phillip Pace, Director

Center for Material Sciences and Engineering

Professor Alan Fox, Director

Center for Reconnaissance Research

Professor John P. Powers, Director

Center for Signal Processing

Professor Charles Therrien, Director

Decision and Information Systems Center

Associate Professor Hemant Bhargava, Director

Institute for Joint Warfare Analysis (IJWA)

Professor Gordon Schacher, Acting Director

Joint Center for International and Security Studies (JCISS)

Research Associate Professor Jan Breemer, Director

Navy-NASA Joint Institute of Aeronautics

Distinguished Professor Max Platzer, Director

Research Center for Military Applications of Space

Alan Ross, Navy TENCAP Chair and Director

Software Metrics Center

Professor Norman Schneidewind, Director

Spacecraft Research and Design Center

Professor Brij Agrawal, Director

Vertical Flight Technology Center

Professor E. Roberts Wood, Director

**Comments/inquiries regarding *Research News*
can be addressed via e-mail to:**

research@nps.navy.mil.

**Additional information about Research at NPS
can be found at <http://web.nps.navy.mil/~code09/>**